

SECTION 32 05 23
CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section shall cover site work concrete constructed upon the prepared subgrade and in conformance with the lines, grades, thickness, and cross sections shown. Construction shall include the following:
- B. Curb, Gutter, and combination curb and gutter.
- C. Pedestrian Pavement: Walks, crossings, wheelchair curb ramps.
- D. Vehicular Pavement: driveways.
- E. Equipment Pads: transformers.

1.2 DESIGN REQUIREMENTS

Design all elements with the latest published version of applicable codes.

1.3 WEATHER LIMITATIONS

Placement of concrete shall be as specified under Article 3.8, COLD WEATHER and Article 3.7, HOT WEATHER of Section 03 30 00, CAST-IN-PLACE CONCRETE.

1.4 SELECT SUBBASE MATERIAL JOB-MIX

The Contractor shall retain and reimburse a testing laboratory to design a select subbase material mixture and submit a job-mix formula to the Resident Engineer, in writing, for approval. The formula shall include the source of materials, gradation, plasticity index, liquid limit, and laboratory compaction curves indicating maximum density at optimum moisture.

1.5 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:
- B. Manufacturers' Certificates and Data certifying that the following materials conform to the requirements specified.
 - 1. Expansion joint filler
 - 2. Hot poured sealing compound
 - 3. Reinforcement
 - 4. Curing materials
- C. Data and Test Reports: Select subbase material.
 - 1. Job-mix formula.
 - 2. Source, gradation, liquid limit, plasticity index, percentage of wear, and other tests as specified and in referenced publications.

SECTION 32 12 16 ASPHALT PAVING

PART 1 - GENERAL

1.1 DESCRIPTION

This work shall cover the composition, mixing, construction upon the prepared subgrade, and the protection of hot asphalt concrete pavement. The hot asphalt concrete pavement shall consist of an aggregate or asphalt base course and asphalt surface course constructed in conformity with the lines, grades, thickness, and cross sections as shown. Each course shall be constructed to the depth, section, or elevation required by the drawings and shall be rolled, finished, and approved before the placement of the next course.

1.2 INSPECTION OF PLANT AND EQUIPMENT

The Resident Engineer shall have access at all times to all parts of the material producing plants for checking the mixing operations and materials and the adequacy of the equipment in use.

1.3 ALIGNMENT AND GRADE CONTROL

The Contractor's Registered Professional Land Surveyor shall establish and control the pavement (aggregate or asphalt base course and asphalt surface course) alignments, grades, elevations, and cross sections as shown on the Drawings.

1.4 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish the following:
- B. Data and Test Reports:
 - 1. Aggregate Base Course: Sources, gradation, liquid limit, plasticity index, percentage of wear, and other tests required by State Highway Department.
 - 2. Asphalt Base/Surface Course: Aggregate source, gradation, soundness loss, percentage of wear, and other tests required by State Highway Department.
 - 3. Job-mix formula.
- C. Certifications:
 - 1. Asphalt prime and tack coat material certificate of conformance to State Highway Department requirements.
 - 2. Asphalt cement certificate of conformance to State Highway Department requirements.
 - 3. Job-mix certification - Submit plant mix certification that mix equals or exceeds the State Highway Specification.
- D. One copy of State Highway Department Specifications.
- E. Provide MSDS (Material Safety Data Sheets) for all chemicals used on ground.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Aggregate base and asphalt concrete materials shall conform to the requirements of the following and other appropriate sections of the latest version of the State Highway Material Specifications, including amendments, addenda and errata. Where the term "Engineer" or "Commission" is referenced in the State Highway Specifications, it shall mean the VA Resident Engineer or VA Contracting Officer.

2.2 AGGREGATES

- A. Provide aggregates consisting of crushed stone, gravel, sand, or other sound, durable mineral materials processed and blended, and naturally combined.
- B. Subbase aggregate (where required) maximum size: 38mm(1-1/2").
- C. Base aggregate maximum size:
1. Base course over 152mm(6") thick: 38mm(1-1/2");
 2. Other base courses: 19mm(3/4").
- D. Asphaltic base course:
1. Maximum particle size not to exceed 25.4mm(1").
 2. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.
- E. Aggregates for asphaltic concrete paving: Provide a mixture of sand, mineral aggregate, and liquid asphalt mixed in such proportions that the percentage by weight will be within:

<u>Sieve Sizes</u>	<u>Percentage Passing</u>
19mm(3/4")	100
9.5mm(3/8")	67 to 85
6.4mm(1/4")	50 to 65
2.4mm(No. 8 mesh)	37 to 50
600µm(No. 30 mesh)	15 to 25
75µm(No. 200 mesh)	3 to 8

plus 50/60 penetration liquid asphalt at 5 percent to 6-1/2 percent of the combined dry aggregates.

2.3 ASPHALTS

- A. Comply with provisions of Asphalt Institute Specification SS2:
1. Asphalt cement: Penetration grade 50/60
 2. Prime coat: Cut-back type, grade MC-250

3. Tack coat: Uniformly emulsified, grade SS-1H

2.4 SEALER

- A. Provide a sealer consisting of suitable fibrated chemical type asphalt base binders and fillers having a container consistency suitable for troweling after thorough stirring, and containing no clay or other deleterious substance.
- B. Where conflicts arise between this specification and the requirements in the latest version of the State Highway Specifications, the State Specifications shall control.

PART 3 - EXECUTION

3.1 GENERAL

The Asphalt Concrete Paving equipment, weather limitations, job-mix formula, mixing, construction methods, compaction, finishing, tolerance, and protection shall conform to the requirements of the appropriate sections of the State Highway Specifications for the type of material specified.

3.2 MIXING ASPHALTIC CONCRETE MATERIALS

- A. Provide hot plant-mixed asphaltic concrete paving materials.
 - 1. Temperature leaving the plant: 143 degrees C(290 degrees F) minimum, 160 degrees C(320 degrees F) maximum.
 - 2. Temperature at time of placing: 138 degrees C(280 degrees F) minimum.

3.3 SUBGRADE

- A. Shape to line and grade and compact with self-propelled rollers.
- B. All depressions that develop under rolling shall be filled with acceptable material and the area re-rolled.
- C. Soft areas shall be removed and filled with acceptable materials and the area re-rolled.
- D. Should the subgrade become rutted or displaced prior to the placing of the subbase, it shall be reworked to bring to line and grade.
- E. Proof-roll the subgrade with maximum 45 tonne (50 ton) gross weight dump truck as directed by VA Resident Engineer or VA Contracting Officer. If pumping, pushing, or other movement is observed, rework the area to provide a stable and compacted subgrade.

3.4 BASE COURSES

- A. Subbase (when required)
 - 1. Spread and compact to the thickness shown on the drawings.
 - 2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.
 - 3. After completion of the subbase rolling there shall be no hauling over the subbase other than the delivery of material for the top course.

B. Base

1. Spread and compact to the thickness shown on the drawings.
2. Rolling shall begin at the sides and continue toward the center and shall continue until there is no movement ahead of the roller.
3. After completion of the base rolling there shall be no hauling over the base other than the delivery of material for the top course.

C. Thickness tolerance: Provide the compacted thicknesses shown on the Drawings within a tolerance of minus 0.0mm (0.0") to plus 12.7mm (0.5").

D. Smoothness tolerance: Provide the lines and grades shown on the Drawings within a tolerance of 5mm in 3m (3/16 inch in ten feet).

E. Moisture content: Use only the amount of moisture needed to achieve the specified compaction.

3.5 PLACEMENT OF ASPHALTIC CONCRETE PAVING

A. Remove all loose materials from the compacted base.

B. Apply the specified prime coat, and tack coat where required, and allow to dry in accordance with the manufacturer's recommendations as approved by the Architect or Engineer.

C. Receipt of asphaltic concrete materials:

1. Do not accept material unless it is covered with a tarpaulin until unloaded, and unless the material has a temperature of not less than 130 degrees C(280 degrees F).
2. Do not commence placement of asphaltic concrete materials when the atmospheric temperature is below 10 degrees C (50 degrees F), not during fog, rain, or other unsuitable conditions.

D. Spreading:

1. Spread material in a manner that requires the least handling.
2. Where thickness of finished paving will be 76mm (3") or less, spread in one layer.

E. Rolling:

1. After the material has been spread to the proper depth, roll until the surface is hard, smooth, unyielding, and true to the thickness and elevations shown on the drawings.
2. Roll in at least two directions until no roller marks are visible.
3. Finished paving smoothness tolerance:
 - a. No depressions which will retain standing water.
 - b. No deviation greater than 3mm in 1.8m (1/8" in six feet).

3.6 APPLICATION OF SEAL COAT

A. Prepare the surfaces, mix the seal coat material, and apply in accordance with the manufacturer's recommendations as approved by the Architect or Engineer.

B. Apply one coat of the specified sealer.

- C. Achieve a finished surface seal which, when dry and thoroughly set, is smooth, tough, resilient, of uniform black color, and free from coarse textured areas, lap marks, ridges, and other surface irregularities.

3.7 PROTECTION

Protect the asphaltic concrete paved areas from traffic until the sealer is set and cured and does not pick up under foot or wheeled traffic.

3.8 FINAL CLEAN-UP

Remove all debris, rubbish, and excess material from the work area.

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**SECTION 32 17 23
PAVEMENT MARKINGS**

PART 1 - GENERAL

1.1 DESCRIPTION

This work shall consist of furnishing and applying paint on pavement surfaces, in the form of traffic lanes, parking bays, areas restricted to handicapped persons, crosswalks, and other detail pavement markings, in accordance with the details as shown or as prescribed by the Resident Engineer. Conform to the Manual on Uniform Traffic Control Devices for Streets and Highways, published by the U.S. Department of Transportation, Federal Highway Administration, for details not shown.

1.2 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish Manufacturer's Certificates and Data certifying that the following materials conform to the requirements specified.
- B. Paint.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Federal Specifications (Fed. Spec.):
 - TT-B-1325C Beads (Glass Spheres); Retro-Reflective
 - TT-P-1952D Paint, Traffic Black, and Airfield Marking, Waterborne
- C. Master Painters Institute (MPI):
 - Approved Product List - 2010

PART 2 - PRODUCTS

2.1 PAINT

Paint for marking pavement (parking lot and zone marking) shall conform to MPI No. 97, color as shown. Paint for obliterating existing markings shall conform to Fed. Spec. TT-P-1952D. Paint shall be in containers of at least 18 L (5 gallons). A certificate shall accompany each batch of paint stating compliance with the applicable publication.

2.2 PAINT APPLICATOR

Apply all marking by approved mechanical equipment. The equipment shall provide constant agitation of paint and travel at controlled speeds. Synchronize one or more paint "guns" to

automatically begin and cut off paint flow in the case of skip lines. The equipment shall have manual control to apply continuous lines of varying length and marking widths as shown. Provide pneumatic spray guns for hand application of paint in areas where a mobile paint applicator cannot be used. An experienced technician that is thoroughly familiar with equipment, materials, and marking layouts shall control all painting equipment and operations.

2.3 SANDBLASTING EQUIPMENT

Sandblasting equipment shall include an air compressor, hoses, and nozzles of proper size and capacity as required for cleaning surfaces to be painted. The compressor shall furnish not less than 0.08 m³/s (150 cfm) of air at a pressure of not less than 625 kPa (90 psi) at each nozzle used.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

- A. Allow new pavement surfaces to cure for a period of not less than 14 days before application of marking materials.
- B. Thoroughly clean all surfaces to be marked before application of paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods. Completely remove rubber deposits, existing paint markings, and other coatings adhering to the pavement with scrapers, wire brushings, sandblasting, mechanical abrasion, or approved chemicals as directed by the Resident Engineer. The application of paint conforming to Fed. Spec. TT-P-1952D is an option to removal of existing paint markings on asphalt pavement. Apply the black paint in as many coats as necessary to completely obliterate the existing markings. Where oil or grease are present on old pavements to be marked, scrub affected areas with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application. After cleaning, seal oil-soaked areas with cut shellac to prevent bleeding through the new paint. Pavement marking shall follow as closely as practicable after the surface has been cleaned and dried, but do not begin any marking until the Resident Engineer has inspected the surface and gives permission to proceed. The Contractor shall establish control points for marking and provide templates to control paint application by type and color at necessary intervals. The Contractor is responsible to preserve and apply marking in conformance with the established control points.

3.2 APPLICATION

Apply uniformly painted pavement marking of required color(s), length, and width with true, sharp edges and ends on properly cured, prepared, and dried surfaces in conformance with the details

as shown and established control points. The length and width of lines shall conform within a tolerance of plus or minus 75 mm (3 inches) and plus or minus 3 mm (1/8 inch), respectively, in the case of skip markings. The length of intervals shall not exceed the line length tolerance. Temperature of the surface to be painted and the atmosphere shall be above 10°C (50°F) and less than 35°C (95°F). Apply the paint at a wet film thickness of 0.4 mm (0.015 inch). Apply paint in one coat. At the direction of the Resident Engineer, markings showing light spots may receive additional coats. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of asphalt, and pick-up, displacement, or discoloration by tires of traffic. If there is a deficiency in drying of the marking, discontinue paint operations until cause of the slow drying is determined and corrected. Remove and replace marking that is applied at less than minimum material rates; deviates from true alignment; exceeds stipulated length and width tolerances; or shows light spots, smears, or other deficiencies or irregularities. Use carefully controlled sand blasting, approved grinding equipment, or other approved method to remove marking so that the surface to which the marking was applied will not be damaged.

3.3 PROTECTION

Conduct operations in such a manner that necessary traffic can move without hindrance. Protect the newly painted markings so that, insofar as possible, the tires of passing vehicles will not pick up paint. Place warning signs at the beginning of the wet line, and at points well in advance of the marking equipment for alerting approaching traffic from both directions. Place small flags or other similarly effective small objects near freshly applied markings at frequent intervals to reduce crossing by traffic. Efface and replace damaged portions of markings at no additional cost to the Government.

3.4 DETAIL PAVEMENT MARKING

Use Detail Pavement Markings, exclusive of actual traffic lane marking, at exit and entrance islands and turnouts, on curbs, at crosswalks, at parking bays, and at such other locations as shown. Show the International Handicapped Symbol at indicated parking spaces. Color shall be as shown. Apply paint for the symbol using a suitable template that will provide a pavement marking with true, sharp edges and ends. Place detail pavement markings of the color(s), width(s) and length(s), and design pattern at the locations shown.

3.5 TEMPORARY PAVEMENT MARKING

When shown or directed by the Resident Engineer, apply Temporary Pavement Markings of the color(s), width(s) and length(s) shown or directed. After the temporary marking has served its purpose and when so ordered by the Resident Engineer, remove temporary marking by carefully controlled sandblasting, approved grinding equipment, or other approved method so that the

surface to which the marking was applied will not be damaged. As an option, an approved preformed pressure sensitive, adhesive tape type of temporary pavement marking of the required color(s), width(s) and length(s) may be furnished and used in lieu of temporary painted marking. The Contractor shall be fully responsible for the continued durability and effectiveness of such marking during the period for which its use is required. Remove any unsatisfactory tape type marking and replace with painted markings at no additional cost to the Government.

3.6 FINAL CLEAN-UP

Remove all debris, rubbish and excess material from the Station.

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SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 – GENERAL

1.1 DESCRIPTION

This work consists of all labor, materials, and equipment necessary for furnishing and installing chain link fence, gates and accessories in conformance with the lines, grades, and details as shown.

1.2 MANUFACTURER'S QUALIFICATIONS

Fence, gates, and accessories shall be products of manufacturers' regularly engaged in manufacturing items of type specified.

1.3 SUBMITTALS

- A. In accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES, furnish the following:
 - 1. Manufacturer's Literature and Data: Chain link fencing, gates and all accessories.
 - 2. Manufacturer's Certificates: Zinc-coating complies with specifications.
- C. Certification that fence alignment meets requirements of contract documents.

1.4 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):
 - A121-07 Metallic Coated Carbon Steel Barbed Wire
 - A392-07 Zinc-Coated Steel Chain-Link Fence Fabric
 - A817-07 Metal-Coated Steel Wire for Chain-Link Fence Fabric and
Marcelled Tension Wire
 - C94/C94M-07 Ready-Mixed Concrete
 - F567-07 Installation of Chain-Link Fence
 - F626-(R2003) Fence Fittings
 - F900-05 Industrial and Commercial Swing Gates
 - F1043-06 Strength and Protective Coatings on Metal Industrial Chain-Link
Fence Framework
 - F1083-08 Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for
Fence Structures.
- C. Federal Specifications (Fed. Spec.):
 - FF-P-110J Padlock, Changeable Combination

PART 2 - PRODUCTS

2.1 GENERAL

Materials shall conform to ASTM F1083 and ASTM A392 ferrous metals, zinc-coated; and detailed specifications forming the various parts thereto; and other requirements specified herein. Zinc-coat metal members (including fabric, gates, posts, rails, hardware and other ferrous metal items) after fabrication shall be reasonably free of excessive roughness, blisters and sal-ammoniac spots.

2.2 CHAIN-LINK FABRIC

ASTM A392 9 gauge wire woven in a 50 mm (2 inch) mesh. Top and bottom selvage shall have twisted and barbed finish. Zinc-coating weight shall be 570 grams/m² (2.0 ounces per square foot).

2.3 POST, FOR GATES AND FENCING

ASTM F1083, Grade SK-40A, round, zinc-coated steel. Dimensions and weights of posts shall conform to the tables in the ASTM Specification. Provide post braces and truss rods for each gate, corner, pull or end post. Provide truss rods with turnbuckles or other equivalent provisions for adjustment.

2.4 TOP RAIL AND BOTTOM RAIL

ASTM F1083, Grade SK-40A, round, zinc-coated steel. Dimensions and weights of posts shall conform to the tables in the ASTM Specification; fitted with suitable expansion sleeves and means for securing rail to each gate, corner, and end posts.

2.5 TOP AND BOTTOM TENSION WIRE

ASTM A817 and ASTM F626, zinc-coated, having minimum coating the same as the fence fabric.

2.6 ACCESSORIES

Accessories as necessary caps, rail and brace ends, wire ties or clips, braces and tension bands, tension bars, truss rods, and miscellaneous accessories conforming to ASTM F626

2.9 GATES

ASTM F900, type as shown. Gate framing, bracing, latches, and other hardware zinc-coating weight shall be the same as the FABRIC. Gate leaves more than 2400 mm (8 feet) wide shall have either intermediate members and diagonal truss rods, or shall have tubular members as necessary to provide rigid construction, free from sag or twist. Gates less than 2400 mm (8 feet) wide shall have truss rods or intermediate braces. Attach gate fabric to the gate frame by method standard with the manufacturer, except that welding will not be permitted. Arrange latches for padlocking so that padlock will be accessible from both sides of the gate regardless of the latching arrangement. When required, extend each end member of gate frame sufficiently above

the top member or provide three strands of barbed wire in horizontal alignment with barbed wire strands on the fence.

2.10 GATE HARDWARE

- A. Manufacturer's standard products, installed complete. The type of hinges shall allow gates to swing through 180 degrees, from closed to open position. Hang and secure gates in such a manner that, when locked, they cannot be lifted off hinges.
- B. Provide stops and keepers for all double gates. Latches shall have a plunger-bar arranged to engage the center stop. Arrange latches for locking. Center stops shall consist of a device arranged to be set in concrete and to engage a plunger bar. Keepers shall consist of a mechanical device for securing the free end of the gate when in full open position.
- C. Padlocks for gates are specified under Section 08 71 00, DOOR HARDWARE. Padlocks shall have chains that are securely attached to the gate or gate post.
- D. Equip gate openings with padlock conforming to Fed Spec FF-P-110H, Type EPC, size 50 mm (2 inch). Padlocks shall have chains that are securely attached to the gate or gate post. Before padlocks are delivered to project, submit sample to Resident Engineer for approval. Approved sample may be incorporated in work. Key padlock as directed by the Resident Engineer.

2.11 CONCRETE

ASTM C94/C94M, using 19 mm (3/4 inch) maximum-size aggregate, and having minimum compressive strength of 25 mPa (3000 psig) at 28 days. Non-shrinking grout shall consist of one part Portland cement to three parts clean, well-graded sand, non-shrinking grout additive and the minimum amount of water to produce a workable mix.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fence by properly trained crew, on previously prepared surfaces, to line and grade as shown. Install fence in accordance with ASTM F567 and with the manufacturer's printed installation instructions, except as modified herein or as shown. Maintain all equipment, tools, and machinery while on the project in sufficient quantities and capacities for proper installation of posts, chain links and accessories.
- B. A Registered Professional Land Surveyor or Registered Civil Engineer specified in Section 01 00 00, GENERAL REQUIREMENTS, shall stake out and certify the fence alignment to meet the requirements as shown.

3.2 EXCAVATION

Excavation for concrete-embedded items shall be of the dimensions shown, except in bedrock. If bedrock is encountered before reaching the required depth, continue the excavation to the depth shown or 450 mm (18 inches) into the bedrock, whichever is less, and provide a minimum of 50

mm (2 inches) larger diameter than the outside diameter of the post. Clear loose material from post holes. Grade area around finished concrete footings as shown and dispose of excess earth as directed by the Resident Engineer.

3.3 POST SETTING

Install posts plumb and in alignment. Set post in concrete footings of dimensions as shown, except in bedrock. Thoroughly compact concrete so as it to be free of voids and finished in a slope or dome to divert water running down the post away from the footing. Straight runs between braced posts shall not exceed 150 m (500 feet). Install posts in bedrock with a minimum of 25 mm (one inch) of non-shrinking grout around each post. Thoroughly work non-shrinking grout into the hole so as to be free of voids and finished in a slope or dome. Cure concrete and grout a minimum of 72 hours before any further work is done on the posts.

3.4 POST SETTING IN STRUCTURES

Install post in retaining walls, curbs, concrete slabs, or similar construction in proper size galvanized pipe sleeves set into the concrete or built into the masonry as shown. Set sleeves plumb and 13 mm (1/2 inch) above the finished structure. Fill space solidly between sleeve and post with non-shrinking grout, molten lead, or sulphur, and finish to divert water running down the post away from the post base.

3.5 POST CAPS

Fit all exposed ends of post with caps. Provide caps that fit snugly and are weathertight. Where top rail is used, provide caps to accommodate the top rail. Install post caps as recommended by the manufacturer and as shown.

3.6 SUPPORTING ARMS

Design supporting arms, when required, to be weathertight. Where top rail is used, provide arms to accommodate the top rail. Install supporting arms as recommended by the manufacturer and as shown.

3.8 TOP AND BOTTOM TENSION WIRE

Install and pull taut tension wire before installing the chain-link fabric.

3.9 ACCESSORIES

Supply accessories (posts braces, tension bands, tension bars, truss rods, and miscellaneous accessories), as required and recommended by the manufacturer, to accommodate the installation of a complete fence, with fabric that is taut and attached properly to posts, rails, and tension wire.

3.10 FABRIC

Pull fabric taut and secured with wire ties or clips to the top rail bottom rail and tension wire close to both sides of each post and at intervals of not more than 600 mm (24 inches) on centers. Secure fabric to posts using stretcher bars and ties or clips.

3.11 BARBED WIRE

Install barbed wire, when required, on supporting arms above the fence posts. Extend each end member of gate frames sufficiently above the top member to carry three strands of barbed wire in horizontal alignment with barbed wire strands on the fence. Pull each strand taut and securely fasten to each supporting arm and extended member.

3.12 GATES

Install gates plumb, level, and secure for full opening without interference. Set keepers, stops and other accessories into concrete as required by the manufacturer and as shown. Adjust hardware for smooth operation and lubricate where necessary.

3.13 REPAIR OF GALVANIZED SURFACES

Use galvanized repair compound, stick form, or other method, where galvanized surfaces need field or shop repair. Repair surfaces in accordance with the manufacturer's printed directions.

3.14 FINAL CLEAN-UP

Remove all debris, rubbish and excess material from the station.

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**SECTION 33 10 00
WATER UTILITIES**

PART 1 - GENERAL

1.1 DESCRIPTION:

Underground water distribution system complete, ready for operation, including all appurtenant structures, and connections to both new building service lines and to existing water supply.

1.2 RELATED WORK:

- A. Maintenance of Existing Utilities: Section 01 00 00, GENERAL REQUIREMENTS.
- B. Excavation, trench widths, pipe bedding, backfill, shoring, sheeting, bracing: Section 31 20 00, EARTH MOVING.
- C. Concrete: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- D. Protection of materials and equipment: Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 DEFINITIONS:

- A. Water Distribution: Pipelines and appurtenances which are part of the distribution system. The distribution system comprises the network of piping located throughout building areas and other areas of water use, including hydrants, valves, and other appurtenances used to supply water for domestic and fire-fighting/fire protection purposes.
- B. Water Service Line: Pipe line connecting building piping to water distribution lines.

1.4 QUALITY ASSURANCE:

- A. Products Criteria:
 - 1. Multiple Units: When two or more units of the same type or class of materials or equipment are required, these units shall be product of one manufacturer.
 - 2. Nameplate: Nameplate bearing manufacturer's name or identifiable trademark securely affixed in a conspicuous place on equipment or name or trademark cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.
- B. Comply with the rules and regulations of the Public Utility having jurisdiction over the connection to Public Water lines and the extension, and/or modifications to Public Utility systems.
- C. Comply with all rules and regulations of Federal, State, and Local Department of Environmental Quality having jurisdiction over the design, construction, and operation of potable water systems.
- D. All material surfaces in contact with potable water shall comply with NSF 61.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturers' Literature and Data (Submit all items as one package):

(Ductile Iron Pipe and Polyvinyl Chloride (PVC) shall be in accordance with AWWA C600 and C605 respectively; and shall be provided to Resident Engineer for approval.)

1. Piping.
 2. Gaskets.
 3. Valves.
 4. Fire hydrants.
 5. Street washer.
 6. Meter.
 7. Vaults, frames and covers.
 8. Steps.
 9. Post indicator.
 10. Valve boxes.
 11. Corporation and curb stops.
 12. Curb stop boxes.
 13. Joint restraint.
 14. Disinfection products.
 15. Link/sleeve seals.
- C. Testing Certifications:
1. Certification of Backflow Devices.
 2. Hydrostatic Testing.
 3. Certification of Disinfection, including free chlorine residuals, and bacteriological examinations.

1.6 APPLICABLE PUBLICATIONS:

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute (ANSI/ASME):
- B16.1-98 Cast Iron Pipe Flanges and Flanged Fittings
 - B16.18..... Cast Bronze Solder Joint Pressure Fittings
 - B16.26-88 Cast Copper Alloy Fittings for Flared Copper Tubes
 - B40.100-98 Pressure Gauges and Gauge Attachments
- C. American Society for Testing and Materials (ASTM):
- A123-97 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - A148M-03 Standard Specifications for Steel Castings
 - A242-00 Standard Specifications for High Strength Low Alloy Structural Steel AASHTO No. M161
 - A307-02 Standard Specifications for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

- A536-04 Standard Specifications for Ductile Iron Castings
- B61-02 Steam or Valve Bronze Castings
- B62-02 Composition Bronze or Ounce Metal Castings
- B88-02 Seamless Copper Water Tube
- B828 Standard Practice: Soldering and Brazing Copper Tube and fittings
- C32-04 Sewer and Manhole Brick (Made from Clay or Shale)
- C139-03 Concrete Masonry Units for Construction of Catch Basins and Manholes
- D1784-03 Standard Specifications for Rigid PVC Compounds and CPVC Compounds
- D1869-00 Standard Specifications for Rubber Rings for Asbestos Cement Pipe
- D2464-99 Standard Specifications for Threaded PVC Pipe Fittings, Schedule 80
- D2467-02 Standard Specifications for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
- D3139-98 Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
- F477-02e1 Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- C32-04 Standard Specifications for Sewer Manhole Brick
- D. American Water Works Association (AWWA):
 - B300-04 Hypochlorites
 - B301-04 Liquid Chlorine
 - C104-04 Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water
 - C105-99 Polyethylene Encasement for Gray and Ductile C.I. Piping for Water and Other Liquids
 - C110-03 Ductile-Iron and Gray-Iron Fittings, 80 mm (3 Inches) Through 1200 mm (48 Inches) for Water and Other Liquids
 - C111-01 Rubber-Gasket Joints for Ductile-Iron and Gray-Iron Pressure Pipe and Fittings
 - C115-99 Flanged Ductile-Iron and Gray-Iron Pipe with Threaded Flanges
 - C150-02 American National Standard for Thickness Design of Ductile Iron Pipe
 - C151-96 Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids

- C153-00 Ductile-Iron Compact Fittings, 80 mm (3 inches) Through 300 mm (12 Inches) for Water and Other Liquids
- C500-02 Gate Valves for Water and Sewerage Systems
- C502a-95 Dry-Barrel Fire Hydrants
- C503-97 Wet-Barrel Fire Hydrants
- C508-01 Swing Check Valves for Waterworks Service, 2 Inches (50 mm) Through 24 Inches (600mm) NPS
- C509-01 Resilient Seated Gate Valve for Water and Sewage System
- C510-97 Double Check Valve Back-Flow Prevention Assembly
- C511-97 Reduced Pressure Principle Back-Flow Prevention Assembly
- C550-01 Protective Epoxy Interior Coatings for Valves and Hydrants
- C600-01 Installation for Ductile-Iron Water Mains and Their Appurtenances
- C605-94 Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
- C651-92 Disinfecting Water Mains
- C800-01 Underground Service Line Valves and Fittings
- C900-97 Polyvinyl Chloride (PVC) Pressure Pipe, 4 Inches Thru 12 Inches, for Water
- C905-97 Polyvinyl Chloride (PVC) Pressure Pipe 14 Inches Thru 36 Inches
- E. National Fire Protection Association (NFPA):
 - 24-95 Installation of Private Fire Service Mains and Their Appurtenances
 - 291-01 Fire Flow Testing and Marking of Hydrants
 - 1141-98 Fire Protection in Planned Building Groups
- F. NSF International:
 - 14-03 Plastics Piping Components and Related Materials
 - 61-02 Drinking Water System Components-Health Effects (Sections 1-9)
- G. American Welding Society (AWS):
 - A5.8-04 Brazing Filler Metal
- H. Foundation for Cross-Connection Control and Hydraulic Research-2005
- I. Copper Development Association's Copper Tube Handbook-2005

PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS:

- A. Ductile iron pipe, direct buried:
 - 1. Provide ductile iron pipe conforming to the requirements of AWWA C151, Pressure Class 350 for Pipe 100 mm through 300 mm (4 inches through 12 inches) in diameter and 250 [psi] minimum for pipe larger than 300 mm (12 inches) in diameter, with standard thickness cement mortar lining interior, and interior asphaltic seal coat and exterior asphaltic coating, in accordance with AWWA and ANSI Standards.
 - 2. Below Grade: Supply pipe in lengths not in excess of a nominal 6 m (20 feet) with rubber ring type push-on joints, mechanical joint or approved restrained joint. Provide flange joint pipe where shown on the drawings. Provide mechanical and restrained joint pipe with sufficient quantities of accessories as required for each joint.
 - 3. When a polyethylene encasement over pipe, fittings, and valves is a requirement as indicated on the drawings, the material, installation and workmanship shall conform to applicable sections of AWWA C105. Make provisions to keep the polyethylene from direct exposure to sunlight prior to installation. Backfill following installation without delay to avoid exposure to sunlight.
- B. Ductile Iron Pipe Above Grade or in Below Ground Concrete Pits:
 - 1. Flanged ductile iron pipe, AWWA C115, with factory applied screwed long hub flanges except as otherwise specified hereinafter. Face and drill flanges after being screwed on the pipe, with flanges true to 90 degrees with the pipe axis and flush with end of pipe, ANSI B16.1, 850 kPa (125 psi) or 1725 kPa (250 psi) standard, for the purpose intended.
 - 2. Wall Sleeve Castings: Size and types shown on the drawings and be hot dipped galvanized. Seal strips, where required shall be Link Seal as manufactured by Thunderline Corp., Wayne, Michigan or equal.
 - 3. Pipe Thickness Class: Minimum of Class 53 as defined in AWWA C150 for all sizes of flanged pipe.
 - 4. Rubber Ring Gaskets: Full face type, AWWA C111, 2 mm (1/16 inch) rubber ring gaskets and of approved composition suitable for the required service.
 - 5. Pipe and fittings exposed to view in the finished work are to be painted in accordance with Section 09 91 00, PAINTING. Pipe shall not receive the standard tar or asphalt coat on the outside surfaces but shall be shop primed on the outside with one coat of Kop-Coat No. 621 Rust Inhibitive Primer or equal. Paint color shall match the wall color.
 - 6. Bolts and Nuts on Flanged Fittings: Grade B, ASTM A307. Low alloy, high strength steel in accordance with AWWA C111. Assemble stainless steel bolts and nuts using anti-seize compound to prevent galling.
- C. All Pipe Fittings: Ductile iron with a minimum pressure rating of 2400 kPa (350 psi). Fittings shall meet the requirements of ANSI and AWWA specifications as applicable. Rubber gasket joints shall conform to AWWA C111 for mechanical and push-on type joints. Ball joints shall conform to

AWWA C151 with a separately cast ductile iron bell conforming to ASTM A148. Flanged fittings shall conform to AWWA C115 and be furnished flat faced and drilled to 850 kPa (125 psi) or 1725 kPa (250 psi) template in accordance with ANSI B16.1 with full faced gaskets.

- D. Provide cement mortar lining and bituminous seal coat on the inside of the pipe and fittings in accordance with AWWA C104. Provide standard asphaltic coating on the exterior.
- E. Provide a factory hydrostatic test of not less than 3.5 MPa (500 psi) for all pipe in accordance with AWWA C151.
- F. Provide non-detectable adhesive backed identification tape on top and sides of all buried ductile iron pipe, extended from joint to joint along the length of the pipe and have black lettering identifying the pipe service at no more than 300 mm (12 inch) intervals. According to service, the tape background color shall be as follows: force main/sanitary-green; potable water-blue.

2.2 POLYVINYL CHLORIDE PIPE AND FITTINGS:

- A. Class-Rated Polyvinyl Chloride (PVC) Pipe:
 - 1. PVC pipe and accessories 100 mm to 356 mm (4 inches–14 inches) in diameter, AWWA C900 “Polyvinyl Chloride (PVC) Pressure Pipe”, Class 200, DR 14, cast iron outside diameters, unless otherwise shown or specified.
 - 2. PVC pipe and accessories 400 mm (16 inches) or larger, AWWA C905, “Polyvinyl Chloride Water Transmission Pipe”, Class 235, DR 18, cast iron outside diameters unless otherwise shown or specified. Pipe and accessories shall bear the NSF mark indicating pipe size, manufacturer’s name, AWWA and/or ASTM Specification number, working pressure and production code. Pipe and couplings shall be made in accordance with ASTM D1784.
 - 3. PVC Pipe and Accessories Smaller than 100 mm (4 inches): Schedule 80, meeting the requirements of ASTM D-1785, Type 1, Grade 1. All exposed piping shall be CPVC meeting requirements of ASTM F441.
- B. Joints:
 - 1. Pipe 75 mm (3 inches) and Greater in Diameter: Push-on type with factory installed solid cross section elastomeric ring meeting the requirements of ASTM F-477.
 - 2. Pipe Less Than 75 mm (3 inches) in Diameter: Threaded (ASTM D-2464) or solvent welded (ASTM 2467). Use Teflon tape or liquid Teflon thread lubricant approved for use on plastic on all threaded joints.
- C. Fittings:
 - 1. Class-Rated Pipe 75 mm (3 inches) in Diameter and Greater: Ductile iron with mechanical joints conforming to the requirements of AWWA C153.
 - 2. For Schedule 80 Pipe less than 75 mm (3 inches) in Diameter: Threaded or solvent weld. Threaded PVC fittings shall conform to ASTM D2464. CPVC fittings shall conform to ASTM F437 for threaded fittings and ASTM F439 for solvent weld fittings.

2.3 COPPER PIPE AND TUBING:

Copper Piping: ASTM B88, Type K, or Type L with flared fittings in accordance with AWWA C800, with sweat cast brass fittings per ANSI B16.18. Use brazing alloy, AWS A5.8, Classification BCuP.

2.4 VALVES:

- A. Asbestos packing is not allowed.
- B. Gate:
 - 1. 75 mm (3 inches) and Larger: Resilient seated, ductile iron body, bronze mounted, inclined seats, non-rising stem type turning counter-clockwise to open, 1375 kPa (200 pound) WOG. AWWA C509. The resilient seat shall be fastened to the gate with stainless steel fasteners or vulcanizing methods. The interior and exterior shall be coated with thermo-setting or fusion epoxy coating in accordance with AWWA C550.
 - 2. Operator:
 - a. Underground: Except for use with post indicators, furnish valves with 50 mm (2 inch) nut for socket wrench operation. Post indicator shall comply with the requirements of NFPA 24 and shall be fully compatible with the valve provided.
 - b. Above Ground and in Pits: Hand wheels.
 - 3. Joints: Ends of valves shall accommodate, or be adapted to, pipe installed.
- C. Check: Swing.
 - 1. Smaller than 100 mm (4 inches): Bronze body and bonnet, ASTM B61 or B62, 1375 kPa (200 pound) WOG.
 - 2. 100 mm (4 inches) and Larger: Iron body, bronze trim, swing type, vertical or horizontal installation, flange connection, 1375 kPa (200 pound) WOG. Check valves for fire lines shall conform to AWWA C508 and shall be epoxy coated and lined per AWWA C550.
- D. Corporation stops and saddles shall conform to AWWA C800.
- E. Curb Stop: Smaller than 75 mm (3 inches). Waterworks standard for Type "K" copper, single piece cast bronze body with tee top operated plug sealed with O-ring gaskets, 1375 kPa (200 pound) WOG per AWWA C800.

2.5 CURB STOP BOX:

Cast iron extension box with screw or slide type adjustment and flared base. Box shall be adapted, without full extension, to depth of cover required over pipe at stop location. Cast the word "WATER" in cover and set cover flush with finished grade. Curb stop shut-off rod shall extend 600 mm (2 feet) above top of deepest stop box.

2.6 VALVE BOX:

Cast iron extension box with screw or slide-type adjustment and flared base. Minimum thickness of metal shall be 5 mm (3/16 inch). Box shall be adapted, without full extension, to depth of cover required over pipe at valve location. Cast the word "WATER" in cover. Provide [4] "T" handle

socket wrenches of 16 mm (5/8 inch) round stock long enough to extend 600 mm (2 feet) above top of deepest valve box.

2.7 POST INDICATOR VALVE:

- A. Valve: Valve shall conform to the specifications listed in Section 2.4 for gate valves. The Post Indicator shall conform to NFPA 24, and shall be fully compatible with the valve and all the supervisory switches.

2.8 FIRE HYDRANTS:

- A. Size of main valve opening of each hydrant shall be 125 mm (5 inches), minimum. Hose thread, size of fire apparatus connection, and shape, size and direction of rotation of operating head of hydrant shall be identical with present local fire department and/or water department standards.
- B. Hydrant shall be type AWWA C502, heavy construction, of proper length to connect pipe without extra fittings, and shall be the traffic type with safety flange on barrel and safety couplings on the valve stem with the following features:
 - 1. Interior removable without digging up hydrant; can be packed under pressure; 150 mm (6 inch) bell connection; one steamer nozzle and two hose nozzles with nozzle caps securely chained to barrel; suitable drainage device; single rubber or leather-faced valve in base; nozzles, stuffing boxes, wedge nuts, seat rings, clamp plates, etc. Threaded joints or spindles shall be bronze. Upper and lower barrels shall be of equal diameters. Upper barrel shall be of sufficient length to permit setting hydrant with barrel flange not more than 50 mm (2 inches) above finished grade. All fire hydrants shall have 150 mm (6 inch) bottom connection.
 - 2. Provide fire hydrants with a finish paint identical to the existing fire hydrants.
- C. Provide 4 wrenches with handles not less than 350 mm (14 inches) long.

2.9 PIPE SLEEVES:

Ductile iron or zinc coated steel.

2.10 BACKFLOW PREVENTER:

- A. Potable Water and Irrigation Water Service: Reduced Pressure Principle Type AWWA C511, except pressure drop at rated flow shall not exceed 100 kPa (15 psi). Gate valves installed on the assembly shall be resilient seated valve conforming to AWWA C509.
- B. Fire Service: Double detector check valve. AWWA C510 and NFPA 14.
- C. In cold climate areas, backflow assemblies and devices shall be protected from freezing by a method acceptable to local jurisdiction.
- D. Backflow preventers shall be approved by the Foundation for Cross-Connection Control and Hydraulic Research per current edition of the Manual of Cross-Connection Control.
- E. Backflow preventer shall not be located in any area containing fumes that are toxic, poisonous or corrosive.
- F. Direct connections between potable water piping and sewer connected wastes shall not exist under any condition with or without backflow protection.

- G. Backflow preventer shall be accessed and have clearance for the required testing, maintenance and repair. Access and clearance shall require a minimum of one (1) foot (305 mm) between the lowest portion of the assembly and grade, floor or platform. Installations elevated more than five (5) feet (1524 mm) above the floor or grade shall be provided with a permanent platform capable of supporting a tester or maintenance person.

2.13 WATER METER:

Furnish and install meter approved by Water Service Utility. Forward approval.

2.14 VAULTS (BACKFLOW PREVENTER OR METER):

- A. Top and base shall be reinforced concrete.
- B. Walls shall be reinforced concrete, precast concrete, or segmental block (ASTM C139).

2.15 CAST IRON FRAME AND COVER, STEPS, ETC.:

Cast iron frame and cover, steps, etc. shall comply with State Department of Transportation standard details. Identify cover as "WATER".

2.16 FLEXIBLE EXPANSION JOINTS: (PROVIDE FOR DOMESTIC AND FIRE SERVICE)

Ductile iron with ball joints rated for 1725 kPa (250 PSI) working pressure conforming to ANSI/AWWA A21.53/C153, capable of deflecting a minimum of 30 degrees and expanding simultaneously to the amount shown on the drawings. Flexible expansion joint shall have the expansion capability designed as an integral part of the ductile iron ball castings. Pressure containing parts shall be lined with a minimum of 375 μ m (15 mils) of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213 and shall be factory holiday tested with a 1500 volt spark test. Flexible expansion joint shall have flanged connections conforming to ANSI/AWWA A21.11/C110. Bolts and nuts high strength steel with synthetic gaskets that comply with AWWA C110.

2.17 POTABLE WATER:

Water used for filling, flushing, and disinfection of water mains and appurtenances shall conform to Safe Drinking Water Act.

2.18 DISINFECTION CHLORINE:

- A. Liquid chlorine shall conform to AWWA B301 and AWWA C651.
- B. Sodium hypochlorite shall conform to AWWA B300 with 5 percent to 15 percent available chlorine.
- C. Calcium hypochlorite shall conform to AWWA B300 supplied in granular form or 5.g tablets, and shall contain 65 percent chlorine by weight.

2.19 WARNING TAPE

Standard, 4-Mil polyethylene 76 mm (3 inch) wide tape, detectable type, blue with black letters, and imprinted with "CAUTION BURIED WATER LINE BELOW".

PART 3 - EXECUTION

3.1 BUILDING SERVICE LINES:

Install water service lines to point of connection within approximately 1500 mm (5 feet) outside of buildings to which such service is to be connected and make connections thereto. If building services have not been installed provide temporary caps.

3.2 REGRADING:

Raise or lower existing valve and curb stop boxes and fire hydrants to finish grade in areas being graded.

3.3 PIPE LAYING, GENERAL:

- A. Care shall be taken in loading, transporting, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Resident Engineer.
- B. All pipe and fittings shall be subjected to a careful inspection just prior to being laid or installed. If any defective piping is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional expense to the Government. All pipe and fittings shall be thoroughly cleaned before laying, shall be kept clean until they are used in the work, and when installed or laid, shall conform to the lines and grades required.
- C. All buried piping shall be installed to the lines and grades as shown on the drawings. All underground piping shall slope uniformly between joints where elevations are shown.
- D. Contractor shall exercise extreme care when installing piping to shore up and protect from damage all existing underground water line and power lines, and all existing structures.
- E. Do not lay pipe on unstable material, in wet trench, or when trench or weather conditions are unsuitable.
- F. Do not lay pipe in same trench with other pipes or utilities unless shown otherwise on drawings.
- G. Hold pipe securely in place while joint is being made.
- H. Do not walk on pipes in trenches until covered by layers of earth well tamped in place to a depth of 300 mm (12 inches) over pipe.
- I. Full length of each section of pipe shall rest solidly upon pipe bed with recesses excavated to accommodate bells or joints. Do not lay pipes on wood blocking.
- J. Tees, plugs, caps, bends and hydrants on pipe installed underground shall be anchored. See section 3.7 "PIPE SUPPORTS".
- K. Close pipe openings with caps or plugs during installation. Tightly cover and protect equipment against dirt, water and chemical, or mechanical injury. At completion of all work, thoroughly clean exposed materials and equipment.
- L. Good alignment shall be preserved in laying. The deflection at joints shall not exceed that recommended by the manufacturer.

M. Warning tape shall be continuously placed 300 mm (12 inches) above buried water pipes.

3.4 DUCTILE IRON PIPE:

- A. Installing Pipe: Lay pipe in accordance with AWWA C600 with polyethylene encasement if required in accordance with AWWA C105. Provide a firm even bearing throughout the length of the pipe by tamping selected material at the sides of the pipe up to the spring line.
- B. All pipe shall be sound and clean before laying. When laying is not in progress, the open ends of the pipe shall be closed by watertight plug or other approved means.
- C. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Bevel cut ends of pipe to be used with push-on bell to conform to the manufactured spigot end. Cement lining shall be undamaged.
- D. Jointing Ductile-Iron Pipe:
 - 1. Push-on joints shall be made in strict accordance with the manufacturer's instruction. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe is to be aligned with the bell of the pipe to which it is joined, and pushed home with approved means.
 - 2. Mechanical Joints at Valves, Fittings: Install in strict accordance with AWWA C111. To assemble the joints in the field, thoroughly clean the joint surfaces and rubber gaskets with soapy water before tightening the bolts. Bolts shall be tightened to the specified torque.
 - 3. Ball Joints: Install in strict accordance with the manufacturer's instructions. Where ball joint assemblies occur at the face of structures, the socket end shall be at the structure and ball end assembled to the socket.
 - 4. Flanged joints shall be in accordance with AWWA C115. Flanged joints shall be fitted so that the contact faces bear uniformly on the gasket and then are made up with relatively uniform bolt stress.

3.5 PVC PIPE:

- A. PVC piping shall be installed in strict accordance with the manufacturer's instructions and AWWA 605. Place selected material and thoroughly compacted to one foot above the top of the pipe and thereafter back filled as specified in Section 31 20 00, EARTH MOVING.
- B. Copper Tracer Wire: Copper tracer wire consisting of No. 14 AWG solid, single conductor, insulated copper wire shall be installed in the trench with all piping to permit location of the pipe with electronic detectors. The wire shall not be spiraled around the pipe nor taped to the pipe. Wire connections are to be made by stripping the insulation from the wire and soldering with rosin core solder. Solder joints shall be wrapped with rubber tape and electrical tape. At least every 300 m (1000 feet), provide a 2.3 kg (5 pound) magnesium anode attached to the main tracer wire by solder. The solder joint shall be wrapped with rubber tape and with electrical tape. An anode shall be attached at the end of each line.

- C. Magnetic markers may be used in lieu of copper tracer wire to aid in future pipe locating. Generally, install markers on 6 m (20 foot) centers. If pipe is in a congested piping area, install on 3 m (10 foot) centers. Prepare as-built drawing indicating exact location of magnetic markers.

3.6 COPPER PIPE:

Copper piping shall be installed in accordance with the Copper Development Association's Copper Tube Handbook and manufacturer's recommendations. Copper piping shall be bedded in 150 mm (6 inches) of sand and then back filled as specified in Section 31 20 00, EARTH MOVING.

3.7 PIPE SUPPORTS:

- A. Supports:
1. All piping shall be properly and adequately supported. Hangers, supports, base elbows and tees, and concrete piers and pads shall be provided as indicated on the drawings. If the method of support is not indicated on the drawings, exposed piping shall be supported by hangers wherever the structure is suitable and adequate to carry the superimposed load. Supports shall be placed approximately 2.4 m (8 feet) on centers and at each fitting.
 2. Hangers shall be heavy malleable iron of the adjustable swivel type, split ring type, or the adjustable-swivel, pipe-roll type for horizontal piping and adjustable, wrought iron, clamp type for vertical piping. Flat steel strap or chain hangers are not acceptable unless indicated on the drawings.
 3. Hangers shall be attached to the structure, where possible, by beam clamps and approved concrete inserts set in the forms before concrete is poured. Where this method is impractical, anchor bolts with expanding lead shields, rawl drives, or malleable iron expansion shields will be permitted.
 4. Where hangers cannot be used, the Contractor shall provide pipe saddle supports with pipe column and floor flange.

3.8 RESTRAINED JOINTS:

- A. Sections of piping requiring restrained joints shall be constructed using pipe and fittings with restrained "locked-type" joints and the joints shall be capable of holding against withdrawal for line pressures 50 percent above the normal working pressure but not less than 1375 kPa (200 psi). The pipe and fittings shall be restrained push-on joints or restrained mechanical joints.
- B. The minimum number of restrained joints required for resisting force at fittings and changes in direction of pipe shall be determined from the length of retained pipe on each side of fittings and changes in direction necessary to develop adequate resisting friction with the soil. Restrained pipe length shall be as shown on the drawings.
- C. Restrained joint assemblies with ductile iron mechanical joint pipe shall be "Flex-Ring", "Lok-Ring", or mechanical joint coupled as manufactured by American Cast Iron Pipe Company, "Mega-Lug" or approved equal.

- D. Ductile iron pipe bell and spigot joints shall be restrained with EBBA Iron Sales, Inc. Series 800 Coverall or approved equal.
- E. Ductile iron mechanical joint fittings shall be restrained with EBBA Iron Sales, Inc. Series 1200 Restrainer. The restraining device shall be designed to fit standard mechanical joint bells with standard T head bolts conforming to AWWA C111 and AWWA C153. Glands shall be manufactured of ductile iron conforming to ASTM A536. Set screws shall be hardened ductile iron and require the same torque in all sizes. Steel set screws not permitted. These devices shall have the stated pressure rating with a minimum safety factor of 2:1. Glands shall be listed with Underwriters Laboratories and/or approved by Factory Mutual.
- F. Thrust blocks shall not be permitted.
- G. Where ductile iron pipe manufactured with restrained joints is utilized, all restrained joints shall be fully extended and engaged prior to back filling the trench and pressurizing the pipe.
- H. PVC pipe bell and spigot joints shall be restrained with the Uni-Flange Corp. Series 1350 Restrainer or approved equal. The restraining device and Tee head bolts shall be manufactured of high strength ductile iron meeting ASTM A536. Clamping bolts and nuts shall be manufactured of corrosion resistant high strength, low alloy steel meeting the requirements of ASTM A242.
- I. Ductile iron mechanical joint fittings used with PVC pipe shall be restrained with UNI-Flange Corp. Series 1300 Restrainer, EBBA Iron, Inc, Series 2000PV Mechanical Joint Restrainer Gland, or approved equal. The restraining device and Tee head bolts shall be manufactured of high strength ductile iron meeting ASTM A-536. Clamping bolts and nuts shall be manufactured of corrosion resistant high strength, low alloy steel meeting the requirements of ASTM A242.

3.9 PIPE SEPARATION:

- A. Horizontal Separation-Water Mains and Sewers:
 - 1. Water mains shall be located at least 3 m (10 feet) horizontally from any proposed drain, storm sewer, sanitary or sewer service connection.
 - 2. Water mains may be located closer than 3 m (10 feet) to a sewer line when:
 - a. Local conditions prevent a lateral separation of 3 m (10 feet); and
 - b. The water main invert is at least 450 mm (18 inches) above the crown of the sewer; and
 - c. The water main is either in a separate trench or in the same trench on an undisturbed earth shelf located one side of the sewer.
 - 3. When it is impossible to meet (1) or (2) above, both the water main and drain or sewer shall be constructed of mechanical joint ductile iron pipe. Ductile iron pipe shall comply with the requirements listed in this specification section. The drain or sewer shall be pressure tested to the maximum expected surcharge head before back filling.
- B. Vertical Separation-Water Mains and Sewers:
 - 1. A water main shall be separated from a sewer so that its invert is a minimum of 450 mm (18 inches) above the crown of the drain or sewer whenever water mains cross storm sewers,

- sanitary sewers or sewer service connections. The vertical separation shall be maintained for that portion of the water main located within 10 feet horizontally of any sewer or drain crossed. A length of water main pipe shall be centered over the sewer to be crossed with joints equidistant from the sewer or drain.
2. Both the water main and sewer shall be constructed of slip-on or mechanical joint ductile iron pipe or PVC pipe equivalent to water main standards of construction when:
 - a. It is impossible to obtain the proper vertical separations described in (1) above; or
 - b. The water main passes under a sewer or drain.
 3. A vertical separation of 450 mm (18 inches) between the invert of the sewer or drain and the crown of the water main shall be maintained where a water main crosses under a sewer. Support the sewer or drain lines to prevent settling and breaking the water main.
 4. Construction shall extend on each side of the crossing until the perpendicular distance from the water main to the sewer or drain line is at least 3 m (10 feet).

3.10 SETTING OF VALVES AND BOXES:

- A. Provide a surface concrete pad 450 by 450 by 150 mm (18 by 18 by 6 inches) to protect valve box when valve is not located below pavement.
- B. Clean valve and curb stops interior before installation.
- C. Set valve and curb stop box cover flush with finished grade.
- D. Valves shall be installed plumb and level and in accordance with manufacturer's recommendations.

3.11 SETTING OF FIRE HYDRANTS:

- A. Set center of each hydrant not less than 600 mm (2 feet) nor more than 1800 mm (6 feet) back of edge of road or face of curb. Fire apparatus connection shall face road with center of nozzle 450 mm (18 inches) above finished grade. Set barrel flange not more than 50 mm (2 inches) above finished grade.
- B. Set each hydrant on a slab of stone or concrete not less than 100 mm (4 inches) thick and 375 mm (15 inches) square. The service line to the hydrant, between the tee and the shoe of the hydrant, shall be fully restrained.
- C. Set bases in not less than 0.4 cubic meter (1/2 cubic yard) of crushed rock or gravel placed entirely below hydrant drainage device.
- D. Clean interiors of hydrants of all foreign matter before installation.

3.12 PIPE SLEEVES:

Install where water lines pass through retaining walls, building foundations and floors. Seal with modular mechanical type link seal. Install piping so that no joint occurs within a sleeve. Split sleeves may be installed where existing lines pass through new construction.

3.13 FLUSHING AND DISINFECTING:

- A. Flush and disinfect new water lines in accordance with AWWA C651.

- B. Initial flushing shall obtain a minimum velocity in the main of 0.75 m/sec (2.5 feet per second) at 40 PSI residual pressure in water main. The duration of the flushing shall be adequate to remove all particles from the line.

Pipe Diameter		Flow Required to Produce 2.5 ft/sec(approx.) Velocity in Main		Number of Hydrant Outlets			
				Size of Tap. in. (mm)			
				1(25)	1 ½(38)	2(51)	2 1/2-in (64 mm)
In	(mm)	gpm	(L/sec)	Number of taps on pipe			
4	(100)	100	(6.3)	1	--	--	1
6	(150)	200	(12.6)	--	1	--	1
8	(200)	400	(25.2)	--	2	1	1
10	(250)	600	(37.9)	--	3	2	1
12	(300)	900	(56.8)	--	--	3	2
16	(400)	1,600	(100.9)	--	--	4	2

The backflow preventers shall not be in place during the flushing.

- C. The Contractor shall be responsible to provide the water source for filling, flushing, and disinfecting the lines. Only potable water shall be used, and the Contractor shall provide all required temporary pumps, storage facilities required to complete the specified flushing, and disinfection operations.
- D. The Contractor shall be responsible for the disposal of all water used to flush and disinfect the system in accordance with all governing rules and regulations. The discharge water shall not be allowed to create a nuisance for activities occurring on or adjacent to the site.
- E. The bacteriological test specified in AWWA C651 shall be performed by a laboratory approved by the Department of Environmental Quality of the State. The cost of sampling, transportation, and testing shall be the responsibility of the Contractor.
- F. Re-disinfection and bacteriological testing of failed sections of the system shall be the sole responsibility of the Contractor.
- G. Before backflow preventers are installed, all upstream piping shall be thoroughly flushed.

3.14 HYDROSTATIC TESTING:

- A. Hydrostatic testing of the system shall occur prior to disinfecting the system.
- B. After new system is installed, except for connections to existing system and building, backfill at least 300 mm (12 inches) above pipe barrel, leaving joints exposed. The depth of the backfill shall be adequate to prevent the horizontal and vertical movement of the pipe during testing.
- C. Prior to pressurizing the line, all joint restraints shall be completely installed and inspected.

- D. If the system is tested in sections, and at the temporary caps at connections to the existing system and buildings, the Contractor shall provide and install all required temporary thrust restraints required to safely conduct the test.
- E. The Contractor shall install corporation stops in the line as required to purge the air out of the system. At the completion of the test, all corporation stops shall be capped.
- F. The Contractor shall perform pressure and leakage tests for the new system for 2 hours to 1375 kPa (200 psi). Leakage shall not exceed the following requirements.
 - 1. Copper Tubing: No leaks.
 - 2. Ductile Iron Pipe: AWWA C600. Provide to Resident Engineer office.
 - 3. Polyvinyl Chloride (PVC) AWWA C605. Provide to Resident Engineer office.

3.15 BACKFLOW PREVENTOR TESTING:

- A. All backflow preventers shall be tested and certified for proper operation prior to being placed in operation.
- B. Original copies of the certification shall be submitted to the Resident Engineer.

--- E N D ---

**SECTION 33 30 00
SANITARY SEWERAGE UTILITIES**

PART 1 - GENERAL

1.1 DESCRIPTION:

Outside, underground sanitary sewer system, complete, ready for operation, including all gravity flow lines, pressure (force) lines, manholes, cleanouts, frames, covers, structures, appurtenances, and connections to new building and structure, service lines, existing sanitary sewer lines, and existing sanitary structures, and all other incidentals.

1.2 RELATED WORK:

- A. Maintenance of Existing Utilities: Section 01 00 00, GENERAL REQUIREMENTS.
- B. Excavation, Trench Widths, Pipe Bedding, Backfill, Shoring, Sheeting, Bracing: Section 31 20 00, EARTH MOVING. Dewatering: Section 31 23 19, DEWATERING.
- C. Concrete Work Reinforcing, Placement and Finishing; Section 03 30 00, CAST-IN-PLACE CONCRETE.
- D. Fabrication of Steel Ladders: Section 05 50 00, METAL FABRICATIONS.
- E. Protection of Materials and Equipment: Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 QUALITY ASSURANCE:

- A. Products Criteria:
 - 1. Multiple Units: When two or more units of the same type or class of materials or equipment are required, these units shall be products of one manufacturer.
 - 2. Nameplates: Nameplate bearing manufacturer's name, or identifiable trademark, including model number, securely affixed in a conspicuous place on equipment, or name or trademark, including model number cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.
- B. Comply with the rules and regulations of the Public Utility having jurisdiction over the connection to Public Sanitary Sewer lines and the extension, and/or modifications to Public Utility Systems.

1.4 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturers' Literature and Data: Submit the following as one package:
 - 1. Pipe, Fittings, and, Appurtenances.
 - 2. Jointing Material.
 - 3. Manhole and Structure Material.
 - 4. Frames and Covers.
 - 5. Steps and Ladders.

1.5 APPLICABLE PUBLICATIONS:

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):
- A48/A48M-03 Gray Iron Castings
 - A536-84(2004) Ductile Iron Castings
 - A615/A615M-06 Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
 - A625/A625M-03 Tin Mill Products, Black Plate, Single Reduced
 - A746-03 Ductile Iron Gravity Sewer Pipe
 - C12-06 Installing Vitrified Clay Pipe Lines
 - C76-05b/C76M-05b Reinforced Concrete Culvert, Storm Drain and Sewer Pipe
 - C139-05 Concrete Masonry Units for Construction of Catch Basins and Manholes
 - C150-05 Portland Cement
 - C425-04 Compression Joints for Vitrified Clay Pipe and Fittings
 - C478-06a/C478M-06a Precast Reinforced Concrete Manhole Sections
 - C700-05 Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
 - C828-03 Low-Pressure Air Test of Vitrified Clay Pipe Lines
 - C857-95(2001) Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
 - D698-00ae1 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
 - D2321-05 Underground Installation of Thermoplastic Pipes for Sewers and Other Gravity-Flow Applications
 - D2412-02 Determination of External Loading Characteristics of Plastic Pipe by Parallel- Plate Loading
 - D2992-01 Practice for Obtaining Hydrostatic or Pressure Design Basis for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings
 - D3034-04a Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
 - D3212-96a (2003) e1 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
 - D3261-03 Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
 - D3350-05 Polyethylene Plastics Pipe and Fittings Materials
 - D4101-05a Polypropylene Injection and Extrusion Materials

F477-02e1.....	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
F679-06.....	Poly (vinyl chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
F714-05.....	Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
F794-03.....	Poly (Vinyl Chloride)(PVC) Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
F894-05.....	Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
F949-03.....	Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with Smooth Interior and Fittings

C. American Water Works Association (AWWA):

C105/A21.5-05.....	Polyethylene Encasement for Ductile Iron Pipe Systems
C110/A21.10-03.....	Ductile-Iron and Gray-Iron Fittings for Water
C111/A21.11-00.....	Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings
C115-99	Flanged Ductile-Iron Pipe with Threaded Flanges
C116-03	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron Pipe and Gray Iron Fittings for Water Supply Service
C151-/A21.51-02	Ductile-Iron Pipe, Centrifugally Cast for Water
C153-00	Ductile-Iron Compact Fittings for Water Services
C508-01	Swing Check Valves for Waterworks, 2 inches (50 mm) Through 24 inches (600 mm) NPS
C509-01	Resilient Seated Gate Valves for Water-Supply Service
C515-01	Reduced-Wall, Resilient-Seated Gate Valves For Water Supply Service
C512-04	Air Release, Air/Vacuum, and Combination Air Valves for Waterworks Service
C550-05	Protective Epoxy Interior Coatings for Valves and Hydrants
C600-05	Installation for Ductile-Iron Water Mains and Their Appurtenances
C605-94	Underground Installation of Polyvinyl (PVC) Pressure Pipe and Fittings for Water
C900-97	Polyvinyl Chloride (PVC) Pressure Pipe, 100 mm (4 inches) Through 300 mm (12 inches) for Water Distribution

- C905-97 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 350 mm through 1,200 mm (14 Inches through 48 Inches), for Water Transmission and Distribution
- C906-99 Polyethylene (PE) Pressure Pipes and Fittings, 100 mm through 1575 mm (4 Inches through 63 Inches), for Water Distribution
- D. American Association of State Highway and Transportation Officials (AASHTO):
- M198-05..... Joints for Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants
- E. Uni-Bell PVC Pipe Association:
- Uni-B-6-98..... Recommended Practice Low Pressure Air Testing of Installed Sewer Pipe

PART 2 - PRODUCTS

2.1 PIPING:

- A. Gravity Flow Lines (Pipe and Fittings):
1. Vitrified Clay: Pipe and fittings shall conform to ASTM C700, extra strength, with gasketed bell and spigot end joints. Joints on the pipe and fitting shall conform to ASTM C425.
 2. Polyvinyl Chloride (PVC):
 - a. Pipe and Fittings, 100 to 375 mm (4 to 15 inches) in diameter, shall conform to ASTM D3034, Type PSM, SDR 26. Pipe and fittings shall have elastomeric gasket joints providing a watertight seal when tested in accordance with ASTM D3212. Gaskets shall conform to ASTM F477. Solvent welded joints shall not be permitted.
 - b. Pipe and fittings, 450 to 900 mm (18 to 36 inches) in diameter, shall be solid wall or have a corrugated or ribbed exterior profile and a smooth interior. Pipe shall conform to the following:
 - 1) Pipe and fittings shall conform to ASTM F949 corrugated sewer pipe with a smooth interior. The corrugated outer wall shall be fused to the smooth interwall at the corrugation valley. Pipe and fitting shall have a smooth bell, elastomeric joints conforming to ASTM D3212, and shall have a minimum pipe stiffness of 350 kPa (50 psi) at 5 percent deflection, when tested in accordance with ASTM D2412. Corrugation shall be perpendicular to the axis of the pipe to allow gaskets to be installed on field cut sections of pipe without the requirement for special fittings.
 - 2) Ribbed wall PVC pipe and fittings shall conform to ASTM F794 ribbed sewer pipe with smooth interior pipe and fittings shall have a smooth bell, elastomeric joints conforming to ASTM D3212, and shall have a minimum pipe stiffness of 320 kPa (46 psi) when tested in accordance with ASTM D 2412, at 5 percent vertical deflection. Joints shall not leak at 7.6 m (25 feet) of head under 5 percent deflection.

- 3) Solid wall pipe and fittings shall conform to ASTM F679, SDR 26 pipe and fittings shall gaskets conforming to ASTM F477, and shall be able to withstand a hydrostatic pressure of 345 kPa (50 psi).
3. Ductile Iron Pipe (DIP) for Sanitary Sewer: Shall conform to ASTM A746, thickness Class 51 unless otherwise shown or specified. Joints on pipe and fittings shall be push-on style and conform to AWWA C110 and AWWA C111, rated for 1.03 MPa (150 psi). Exterior coating shall be approximately 0.025 mm (1 mil) asphaltic coating as specified in ASTM A746. Interior lining shall be a catalyzed coal tar epoxy, having a minimum thickness of 0.60 mm (24 mils), a permeability rating of 0.13 perms, direct impact rating of 11.3 Nm (100 in-lbs), an abrasion resistance of 20 liters of sand per mil, and dielectric strength of 250 volts per mil. Pipe and fittings shall be polyethylene encased with 0.20 mm (8 mil) polyethylene sheeting per AWWA C105. Color of polyethylene encasement shall be green.
4. High density polyethylene (HDPE) pipe and fittings 450 mm to 900 mm (18 inches to 36 inches) shall conform to ASTM F894. Pipe and fittings shall have a smooth interwall and profile exterior, and be Class 160. Joints shall be water tight elastomeric gaskets in accordance with ASTM D3212, or thermal welded joints.
- B. Gravity flow lines with secondary containment (pipe and fittings):
 1. Piping systems conveying hazardous materials shall be constructed with a watertight primary (carrier) pipe completely enclosed within a watertight secondary (containment) pipe.
 2. Fiberglass Piping and Fittings: Shall be manufactured in accordance with ASTM D2992 using a filament-winding process. Joints shall be adhesive bonded straight or tapered spigot and bells. Taper angles shall not be greater than 0.5 degrees. The pipe and fittings shall have an integral epoxy resin-rich reinforced liner not less than 0.50 mm (0.020 inch) for carrier pipes, and not less than 0.25 mm (0.010 inch) for containment pipe.
 3. The carrier pipe shall be installed with manufactured spacers to maintain a minimum interstitial space of 19 mm (0.75 inch) between the carrier pipe and the containment pipe.
 4. The piping shall be equipped with adequate monitoring ports to detect the presence of fluids within the containment pipe and for the extraction of fluids from the containment pipe.
- C. Pressure (Force) Lines (Pipe and Fittings):
 1. All pipe and fittings used in the construction of force mains shall be rated for a minimum of 1035 kPa (150 psi).
 2. Ductile Iron: Pipe shall conform to AWWA C151 and C111 with polyethylene lining. Flange joints shall conform to AWWA C115. Lining shall be heat-fused mechanical bond polyethylene having a dielectric strength of 250 volts per mil when fully cured. Lining shall be holiday tested in accordance with AWWA C116. The lining shall be a minimum of 1 mm (40 mil) in the barrel of the pipe, and a minimum of 0.25 mm (10 mil) on the bell and spigot area of the pipe. The lining shall be repaired at all field cuts per the manufacturer's

- recommendations. Joints shall be conformed to AWWA C116. Pipe shall be polyethylene encased per AWWA C105.
3. Ductile iron fittings shall comply with AWWA C110 and AWWA C111. Fittings shall be polyethylene line, as specified for ductile iron pipe. Ductile iron fittings shall be polyethylene encased per AWWA C105.
 4. Polyvinyl Chloride (PVC): PVC pipe 100 mm to 300 mm (4 to 12 inches) shall conform to AWWA C900, Class 150 (DR 18). PVC pipe larger than 300 mm (12 inches) shall conform to AWWA C905, Class 200 (DR 21). Fittings for PVC pipe shall be ductile iron.
 5. High Density Polyethylene (HDPE) pipe and fittings shall be manufactured from PE 3408, high density, extra high molecular weight polyethylene meeting the requirements of ASTM D3350. Pipe shall be manufactured in accordance with ASTM F714, and shall be Class 160 (DR 11). Molded fittings shall be manufactured in accordance with ASTM D3261 and subject to the test required under ASTM D3261. Fabricated fittings shall be made by heat fusion jointing of machined shapes cut from pipe, sheet stock, or molded fittings. Molded and fabricated fittings shall be rated for a minimum working pressure equivalent to the pipe. Joints shall be heat fusion butt joints, flange adapters, or mechanical couplings.
 - a. Flange adapters shall have adequate through-bore length to be clamped in a butt fusion jointing machine without the use of a stub-end holder. The sealing surface of the flanged shall be machined with a series of V-shaped grooves to restrain the gasket against blow out. Back-up rings and flange bolts shall be rated equal to or greater than the mating pipe. All flange adapters shall be equipped with a stainless steel internal pipe stiffener.
 - b. Mechanical couplings shall be sleeve style, restrained coupling. The sleeve and gland shall be epoxy coated and lined and rated for the pressure of the mating pipe. Coupling shall be supplied with stainless steel pipe stiffeners to be installed within the pipe.

2.2 JOINTING MATERIAL:

- A. Gravity Flow Lines:
 1. Vitrified Clay Pipe: Rubber gasket, ASTM C425.
 2. Ductile Iron Pipe: Push-on or mechanical joints, AWWA C111, AWWA C110. Flange joints shall comply with AWWA C115. Flange joints shall only be used in vaults or above-grade.
 3. Polyvinyl Chloride (PVC) Pipe (Gravity Use): Joints, ASTM D3212. Elastomeric gasket, ASTM F477.
 4. High Density Polyethylene (HDPE) pipe and fitting joints, ASTM E-3212, elastomeric gaskets, ASTM F477.
- B. Gravity Flow with Secondary Containment: Tapered or straight bell and spigot with adhesive bond. Completed joint shall be equal or greater than the pressure rating of the pipe.
- C. Pressure (Force) Main:

1. All joints indicated on the drawings as being "restrained" shall be fully restrained and capable of restraining 50 percent above all loads acting on the joint, but not less than 1035 kPa (150 psi). Thrust blocks shall not be permitted.
2. Ductile iron pipe and fittings, mechanical or push-on, conforming to AWWA C110 and C111. Restrained joints shall meet the following requirements:
 - a. Push-on joints shall be restrained by a mechanical locking slot cast integrally in the bell of the pipe or fitting. The spigot shall have a retainer weldment or band. Locking segments, placed in the slots in the bell, shall form a mechanical restraint and prevent the opening of the joint.
 - b. Mechanical joint restraint shall be incorporated into the design of the follower gland. The restraining mechanism shall consist of individually actuated wedges that increase their resistance to pull-out as pressure or external forces increase. The device shall be capable of full mechanical joint deflection during assembly and the flexibility of the joint shall be maintained after burial. The joint restraint ring and its wedging components shall be made of Grade 60-42-10 ductile iron conforming to ASTM A536. The wedges shall be ductile iron heat treated to a minimum hardness of 370 BHN. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell conforming to AWWA C111 and AWWA C153 of the latest revision. Torque limiting twist-off nuts shall be used to insure proper actuation of the restraining wedges. The gland shall be specifically designed for the type of pipe (DIP or PVC) connected to the fitting.
3. Polyvinyl Chloride (PVC) Pipe (Pressure Use):
 - a. Push-on joints shall conform to AWWA C900, C905.
 - b. Push-on gaskets for pipe, ASTM F477.
 - c. Restrained joints shall comply with one of the following:
 - 1) Joints to mechanical ductile iron fittings shall comply with the requirements for ductile iron pipe, except the mechanical joint restraint gland shall be specifically designed for use with PVC pipe.
 - 2) Push-on bell and spigot joints shall be retained with retaining rings and thrust rods. The rings shall be ductile iron conforming to ASTM A536. The rings shall be split style with serrated inside face which grips the pipe when the halves of the ring is assembled together. The ring shall not bear directly on the back of the bell. The rods shall be of adequate size and number to resist all axial movement of the joint.
4. High Density Polyethylene (HDPE) pipe and fittings shall be fusion butt welded, flanged, or mechanical couplings as recommended by the manufacturer. Restrained joints shall be limited to fusion welded and flanged.

2.3 MANHOLES AND VAULTS:

- A. Manholes and vaults shall be constructed of precast concrete segmental blocks, precast reinforced concrete rings, precast reinforced sections, or cast-in-place concrete. The manholes and vaults shall be in accordance with State Department of Transportation or State Roads Commission standard details, and the following:
1. Precast Concrete Segmental Blocks: Blocks shall conform to ASTM C139 and shall not be less than 150 mm (6 inches) thick for manholes to a depth of 3.6m (12 feet); not less than 200 mm (8 inches) thick for manholes deeper than 3.6m (12 feet) deep. Blocks shall be not less than 200 mm (8 inches) in length. Blocks shall be shaped so that joints seal and bond effectively with cement mortar. Parge structure interior and exterior with 15 mm (1/2 inch) of cement mortar applied with a trowel and finished to an even glazed surface.
 2. Precast Reinforced Concrete Rings: Rings or sections shall have an inside diameter as indicated on the drawings, and shall be not less than 1200 mm (48 inches) in diameter. Wall thickness shall conform to requirements of ASTM C76, except that lengths of the sections may be shorter as conditions require. Tops shall conform to ASTM C478. Top section shall be eccentric cone type. Steps on inside wall shall be in the same plane from bottom of structure to manhole cover.
 3. Precast Reinforced Concrete Manhole Risers and Tops: Design, material and installation shall conform to requirements of ASTM C478. Top sections shall be eccentric. Steps on inside wall shall be in the same plane from bottom of structure to manhole cover.
 4. Flat top manhole tops shall be reinforced concrete as detailed on the drawings.
 5. Vaults: Reinforced concrete, as indicated on the plans, or precast reinforced concrete. Concrete for precast sections shall have a minimum compressive strength of 35 MPa (5,000 psi) at 28 days, ASTM A615, Grade 60 reinforcing steel, rated for AASHTO HS20-44 loading with 30 percent impact, and conform to ASTM C857.
 6. Mortar:
 - a. Precast Concrete Segmental Block Structures: By volume, 1 part of Portland cement, 1/4 part lime hydrate, and 3 parts sand.
 - b. Precast Reinforced Concrete Ring and Riser Structures: By volume, 1 part of Portland cement and 2 parts sand. Water in mixture shall produce a stiff, workable mortar, but shall not exceed 21 L (5-1/2 gallons) per sack of cement.
 7. Flexible sealing compound shall be packaged in extruded preformed shape, sized to completely fill the joint between precast sections, and form permanently flexible watertight seal. The sealing compound shall be non-shrink and meet AASHTO M198.
 8. Frames and covers shall be gray cast iron conforming to ASTM A48. The frame and cover shall be rated for HS20-44 loading, have a studded pattern on the cover, and the words "sanitary sewer". The studs and the lettering shall be raised 8 mm (5/16 inch). The cover shall be a minimum of 600 mm (24 inches) in diameter and shall have four 19 mm (3/4 inch) vent

- holes and two lifting slots. The bearing surface of the frame and cover shall be machine finished. The cover shall fit firmly on the frame without movement when subject to traffic.
9. Manhole steps shall be polypropylene plastic coated on a No. 4 deformed rebar conforming to ASTM C478, Polypropylene shall conform to ASTM D4101. Steps shall be a minimum of 406 mm (16 inches) wide and project a minimum of 178 mm (7 inches) away from the wall. The top surface of the step shall have a studded non-slip surface. Steps shall be placed at 300 mm (12 inch) centers.
 10. Ladders, brackets and hardware shall be constructed of welded aluminum, rails shall be 10 mm (3/8 inch) by 63 mm (2-1/2 inches) spaced a minimum of 400 mm (16 inches) apart. Rungs shall be 35 mm (1-3/8 inches) in diameter and have a non-slip surface. Standoffs shall offset the ladder 180 mm (7 inches) from the wall. The ladder assembly shall be rated for a minimum of 2200 N (500 pounds).

2.4 CONCRETE:

Concrete shall have a minimum compressive strength of 20 MPa (3000 psi) at 28 days. The cement shall be Type III conforming to ASTM C150. Concrete shall conform with the provisions of Division 03 of these specifications.

2.5 REINFORCING STEEL:

Reinforcing steel shall be deformed bars, ASTM A615, Grade 40 unless otherwise noted.

2.8 CONCRETE PROTECTIVE COATING:

Concrete coating for the interior of wet wells shall consist of an epoxy blended filler sealer, and a cross linked epoxy phenolic cured, resistant protective coating.

2.9 ACID NEUTRALIZATION TANKS:

Acid neutralization tanks shall be constructed of 6 mm (1/4 inch) plate non code mild carbon steel suitable for rubber type lining with all welds double butt, continuous full welded, non porous and ground smooth and having no crevices, offsets or sharpened edges. The bottom and side walls shall be lined with 6 mm (1/4 inch) thermoplastic sheet lining fused directly to white ceramic lining 50 mm (2 inches) thick laid in Permamite acid and alkali proof mortar. The tank shall include 1050 mm (42 inch) ID manway riser constructed of steel shell with an interior corrosion resistant coating and complete cast iron frame and lid at the finish grade. Neutralizing charge shall be limestone, 75 mm (3 inches) in size.

2.10 GATE VALVES:

- A. AWWA C509, resilient seated gate valves rated for 1360 kPa (200 psi) WSP, reduced-wall resilient seated gates valves may be supplied in accordance with AWWA C515. Asbestos packing is prohibited. The interior and exterior of the valve shall be epoxy coated for AWWA C550.
- B. Operation:
 1. Shall turn counterclockwise to open.

2. Underground: 50 mm (2 inch) nut for socket wrench operation.
 3. Above Ground and In Pits: Handwheels.
- C. Joints: End of valve shall accommodate, or be adapted to, pipe furnished.

2.11 VALVE BOXES:

- A. Cast iron extension box with screw or slide-type adjustment and flared base. Minimum thickness or metal shall be 5 mm (3/16 inch). Box shall be of such length as will be adapted, without full extension, to depth of cover required over pipe at valve location.
- B. Cast the word "SEWER" on the cover.
- C. Provide 4 "T" handle socket wrenches, of 16 mm (5/8 inch) round stock long enough to extend 600 mm (2 feet) above top of deepest valve box.

2.12 CHECK VALVES

Check valves shall be swing-check valves conforming to AWWA C508. The interior and exterior of the valve shall be epoxy coated per AWWA C550. The check valve shall be rated for minimum of 850 kPa (125 psi) working pressure.

2.13 OIL AND GREASE INTERCEPTOR AND GREASE REMOVAL PIT:

- A. Shall be constructed of reinforced precast concrete or cast-in-place concrete of the shape and configuration indicated on the plans. Precast vaults shall be constructed in accordance with ASTM C857 and be rated for HS20-44 loading. The concrete shall have a minimum compressive strength of 35 MPa (5,000 psi) at 28 days, and reinforcement shall comply with ASTM A615, Grade 60. Access to the trap shall be through 600 mm (24 inches) diameter manhole frame and cover or through hinged aluminum access manways.
- B. Baffles shall be constructed of 6 mm (1/4 inch) mild carbon steel with 6 mm (1/4 inch) thermoplastic coating.

2.14 AIR RELEASE VALVE:

Valves shall be combination air release and vacuum valve with a single body. The valves shall be rated for 1025 kPa (150 Psi) working pressure, and conform to AWWA C512. Valve shall be provided with threaded connections, and be mounted on a full opening ball valve which shall isolate the valve from the system.

2.15 CLEANOUT FRAMES AND COVERS:

Frames and covers shall be gray iron casting conforming to ASTM C48. The frame and cover shall be rated for HS20-44 wheel loading, have a studded pattern on its cover, vent holes, and lifting slots. The cover shall fit firmly on the frame without movement when subject to vehicular traffic. The word "SEWER" shall be cast on the cover.

2.16 WARNING TAPE:

Standard, .1mm (4Mil) polyethylene 76 mm (3 inch) wide tape detectable type, green with black letters and imprinted with "CAUTION BURIED SEWER LINE BELOW".

PART 3 - EXECUTION

3.1 BUILDING SERVICE LINES:

- A. Install sanitary sewer service lines to point of connection within approximately 1500 mm (5 feet) outside of buildings where service is required and make connections. Coordinate the invert and location of the service line with the Contractor installing the building lines.
- B. Connections of service line to building piping shall be made after the new sanitary sewer system has been constructed, tested, and accepted for operation by the Resident Engineer. The Contractor shall install all temporary caps or plugs required for testing.
- C. When building services have not been installed at the time when the sanitary sewer system is complete, provide temporary plugs or caps at the ends of all service lines. Mark the location and depth of the service lines with continuous warning tape placed 300 mm (12 inches) above service lines.

3.2 ABANDONED MANHOLES STRUCTURES AND PIPING:

- A. Manholes and Structures Outside of Building Areas: Remove frame and cover, cut and remove the top of an elevation of 600 mm (2 feet) below finished grade. Fill the remaining portion with compacted gravel or crushed rock or concrete.
- B. Manholes and Structures with Building Areas: Remove frame and cover and remove the entire structure and the base.
- C. Piping under and within 1500 mm (5 feet) of building areas shall be abandoned in place and completely filled with 21 MPa (3000 psi) concrete.
- D. Piping outside of building areas shall have all ends of the piping at the limit of the abandonment and within structures and manholes, plugged with concrete, and abandoned in-place.
- E. The Contractor shall comply with all OSHA confined space requirements while working within existing manholes and structures.
- F. When the limit of the abandonment terminates in an existing manhole to remain, the flow line in the bench of the manhole to the abandoned line shall be filled with concrete and shaped to maintain the flowline of the lines to remain.

3.3 REGRADING:

- A. Raise or lower existing manholes and structures frames and covers, cleanout frames and covers and valve boxes in regraded areas to finish grade. Carefully remove, clean and salvage cast iron frames and covers. Adjust the elevation of the top of the manhole or structure as detailed on the drawings. Adjust the elevation of the cleanout pipe riser, and reinstall the cap or plug. Reset cast iron frame and cover, grouting below and around the frame. Install concrete collar around reset frame and cover as specified for new construction.
- B. During periods when work is progressing on adjusting manholes or structures cover elevations, the Contractor shall install a temporary cover above the bench of the structure or manhole. The

temporary cover shall be installed above the high flow elevation within the structure, and shall prevent debris from entering the wastewater stream.

- C. The Contractor shall comply with all OSHA confined space requirements when working within existing structures.

3.4 CONNECTIONS TO EXISTING VA OWNED MANHOLES:

- A. During construction of new connections to existing manholes, it shall be the sole responsibility of the Contractor to maintain continued sanitary sewer service to all buildings and users upstream. The contractor shall provide, install, and maintain all pumping, conveyance system, dams, weirs, etc. required to maintain the continuous flow of sewage. All temporary measures required to meet this requirement shall be subject to the review of the Resident Engineer.
- B. Core existing structure, install pipe at the design invert. Install an elastomeric gasket around the pipe, and grout the interstitial space between the pipe and the core.
- C. The bench of the manhole shall be cleaned and reshaped to provide a smooth flowline for all pipes connected to the manhole.
- D. Connections and alterations to existing manholes shall be constructed so that finished work conforms as nearly as practicable to the applicable requirements specified for new manholes, including concrete and masonry work, cutting and shaping.

3.6 PIPE SEPARATION:

- A. Horizontal Separation - Water Mains and Sewers:
 - 1. Existing and proposed water mains shall be at least 3 meters (10 feet) horizontally from any proposed gravity flow and pressure (force main) sanitary sewer or sewer service connection.
 - 2. Gravity flow mains and pressure (force) mains may be located closer than 3 meters (10 feet) but not closer than 1.8 m (6 feet) to a water main when:
 - a. Local conditions prevent a lateral separation of ten feet; and
 - b. The water main invert is at least 450 mm (18 inches) above the crown of the gravity sewer or 600 mm (24 inches) above the crown of the pressure (force) main; and
 - c. The water main is in a separate trench separated by undisturbed earth.
 - 3. When it is impossible to meet (1) or (2) above, both the water main and sanitary sewer main shall be constructed of push-on or mechanical joint ductile iron pipe. The pipe for the sanitary sewer main shall comply with the specifications for pressure (force) mains, and the water main material shall comply with Section 33 10 00, WATER UTILITIES. The sewer shall be pressure tested as specified for pressure (force) mains before backfilling.
- B. Vertical Separation - Water Mains and Sewers at Crossings:
 - 1. Water mains shall be separated from sewer mains so that the invert of the water main is a minimum of 600 mm (24 inches) above the crown of gravity flow sewer or 1200 mm (48 inches) above the crown of pressure (force) mains. The vertical separation shall be

maintained within 3 meters (10 feet) horizontally of the sewer and water crossing. When these vertical separations are met, no additional protection is required.

2. In no case shall pressure (force) sanitary main cross above, or within 600 mm (24 inches) of water lines.
3. When it is impossible to meet (1) above, the gravity flow sewer may be installed 450 mm (18 inches) above or 300 mm (12 inches) below the water main, provided that both the water main and sewer shall be constructed of push-on or mechanical ductile pipe. Pressure (Force) sewers may be installed 600 mm (24 inches) below the water line provided both the water line and sewer line are constructed of ductile iron pipe. The pipe for the sewer shall conform to the requirements for pressure sewers specified herein. Piping for the water main shall conform to Section 33 10 00, WATER UTILITIES.
4. The required vertical separation between the sewer and the water main shall extend on each side of the crossing until the perpendicular distance from the water main to the sewer line is at least 3 meters (10 feet).

3.7 GENERAL PIPING INSTALLATION:

- A. Lay pipes true to line and grade. Gravity flow sewer shall be laid with bells facing upgrade. Pressure (force) mains shall have the bells facing the direction of flow.
- B. Do not lay pipe on unstable material, in wet trench or when trench and weather conditions are unsuitable for the work.
- C. Support pipe on compacted bedding material. Excavate bell holes only large enough to properly make the joint.
- D. Inspect pipes and fittings, for defects before installation. Defective materials shall be plainly marked and removed from the site. Cut pipe shall have smooth regular ends at right angles to axis of pipe.
- E. Clean interior of all pipe thoroughly before installation. When work is not in progress, open ends of pipe shall be closed securely to prevent entrance of storm water, dirt or other substances.
- F. Lower pipe into trench carefully and bring to proper line, grade, and joint. After jointing, interior of each pipe shall be thoroughly wiped or swabbed to remove any dirt, trash or excess jointing materials.
- G. Do not lay sewer pipe in same trench with another pipe or other utility. Sanitary sewers shall cross at least 600 mm (2 feet) below water lines.
- H. Do not walk on pipe in trenches until covered by layers of bedding or backfill material to a depth of 300 mm (12 inches) over the crown of the pipe.
- I. Warning tape shall be continuously placed 300 mm (12 inches) above sewer pipe
- J. Install gravity sewer line in accordance with the provisions of these specifications and the following standards:
 1. Ductile Iron Piping: AWWA C111 and C600.

2. Vitrified Clay Piping: ASTM C12.
 3. Polyvinyl Chloride (PVC) Piping: ASTM D2321.
 4. High Density Polyethylene (HDPE) Piping: Comply with manufacturer's recommendations with gasketed joints.
- K. Gravity Flow Lines with Secondary Containment:
1. Install per manufacturer's recommendations. Install all pipe centering devices to maintain an interstitial space below the invert of the carrier pipe. Both the carrier and containment pipe shall be tested for leaks.
- L. Installation of Pressure (Force) Mains:
1. Sections of piping listed on the drawings shall be fully restrained using approved joint restraint devices. Joint restraint devices shall be installed in accordance with the manufacturer's recommendations. For devices with twist of nuts, the twist of nuts shall be placed on top of the fitting for the Engineer's inspection. The Contractor shall torque test all bolts, set screws, identified by the Resident Engineer.
 2. Thrust blocks shall not be permitted.
 3. Install pressure (force) mains in accordance with the provisions of these specifications and the following standards:
 - a. Ductile Iron Piping: AWWA C111 and C600.
 - b. Polyvinyl Chloride (PVC) Piping: AWWA C605.
 - c. High Density Polyethylene (HDPE) Piping: Per manufacturer's recommendations.

3.8 MANHOLES AND VAULTS:

- A. General:
1. Circular Structures:
 - a. Precast concrete segmental blocks shall lay true and plumb. All horizontal and vertical joints shall be completely filled with mortar. Parge interior and exterior of structure with 15 mm (1/2 inch) or cement mortar applied with a trowel and finished to an even glazed surface.
 - b. Precast reinforced concrete rings shall be installed true and plumb. The joints between rings and between rings and the base and top, shall be sealed with a preform flexible gasket material specifically manufactured for this type of application. Adjust the length of the rings so that the eccentric conical top section will be at the required elevation. Cutting the conical top section is not acceptable.
 - c. Precast reinforced concrete manhole risers and tops. Install as specified for precast reinforced concrete rings.
 2. Rectangular Structures:
 - a. Reinforced concrete structures shall be installed in accordance with Division 03, CONCRETE.

- b. Precast concrete structures shall be placed on a 200 mm (8 inch) reinforced concrete pad, or be provided with a precast concrete base section. Structures provided with a base section shall be set on 200 mm (8 inches) thick aggregate base course compacted to a minimum of 95 percent of the maximum density as determined by ASTM D698. Set precast section true and plumb. Seal all joints with preform flexible gasket material.
3. Do not build structures when air temperature is 0 degrees C (32 degrees F), or below.
4. Invert channels shall be smooth and semicircular in shape conforming to inside of adjacent sewer section. Make changes in direction of flow with a smooth curve of as large a radius as size of structure will permit. Make changes in size and grade of channels gradually and evenly. Construct invert channels by one of the listed methods:
 - a. Forming directly in concrete base of structure.
 - b. Building up with brick and mortar.
5. Floor of structure outside the channels shall be smooth and slope toward channels not less than 1:12 (1-inch per foot) nor more than 1:6 (2 inches per foot). Bottom slab and benches shall be concrete.
6. The wall that support access rungs or ladder shall be 90 degrees vertical from the floor of structure to manhole cover.
7. Install steps and ladders per the manufacturer's recommendations. Steps and ladders shall not move or flex when used. All loose steps and ladders shall be replaced by the Contractor.
8. Install manhole frames and covers on a mortar bed, and flush with the finish pavement. Frames and covers shall not move when subject to vehicular traffic. Install a concrete collar around the frame to protect the frame from moving until the adjacent pavement is placed. In unpaved areas, the rim elevation shall be 50 mm (2 inches) above the adjacent finish grade. Install a 200 mm (8 inches) thick, by 300 mm (12 inches) concrete collar around the perimeter of the frame. Slope the top of the collar away from the frame.

3.9 SEWER AND MANHOLE SUPPORTS, CONCRETE CRADLES:

Reinforced concrete as detailed on the drawings. The concrete shall not restrict access for future maintenance of the joints within the piping system.

3.11 WET WELLS (PRECAST CONCRETE):

- A. Install the wet well on a 200 mm (8 inches) compacted aggregate base course.
- B. Set precast units level and plumb. Install sealant between all precast.
- C. Core openings for pipe penetrations and seal with a modular seal. Seal shall be "link-seal" or approved equal.
- D. Grout all joints and depressions in the vault. Install concrete protective coating per the manufacturer's recommendations. The final coating shall be applied in two coats, providing a minimum thickness .15 - .20 mm (6-8 mils) dry film thickness per coat.
- E. Set top of wet well 300 mm (12 inches) above finish grade.

- F. Pipe and fittings entering and within the wet well shall be poly lined ductile iron pipe.
- G. All pipe penetrations through the walls of the wet well shall be sealed water tight.

3.12 DRY WELL AND VAULTS:

- A. Install precast concrete vaults on a 200 mm (8 inches) compacted aggregate base course. The floor, walls, and top shall be level and plumb.
- B. Vaults shall be sized as indicated on the drawings. Orientate vault and internal piping, valves and appurtenances to provide access to all valves and appurtenances for operation and maintenance of the equipment.
- C. Paint interior of dry well and vaults with two (2) coats of alkyd enamel masonry paint.

3.13 OIL AND GREASE INTERCEPTOR AND GREASE REMOVAL PIT:

- A. Construct reinforced concrete as shown on the drawing, and in accordance with Division 03, CONCRETE. Install precast units as specified above.
- B. Pipe and Fittings: Ductile iron, polylined, piping shall be used inside of trap, between trap and buildings, and between trap and manhole.
- C. Manways and access manholes shall be set to finish grade providing adequate access to the unit. Slope pavement around the access-way to prevent stormwater from entering the unit.
- D. Install baffles as indicated on the drawings.

3.14 ACID NEUTRALIZING TANKS:

- A. Set tank on a 200 mm (8 inches) compacted sand base per the manufacturer's recommendations.
- B. Inspect interior and exterior of the tank and repair all damage to the lining. Place limestone in tank.
- C. Backfill around tank with sand material.

3.15 CLEANOUTS:

- A. 150 millimeters (6 inches) in diameter and consisting of a ductile iron 45 degree fitting on end of run, or combination Y fitting and 1/8 bend in the run with ductile iron pipe extension, water tight plug or cap and cast frame and cover flush with finished grade. Center-set cleanouts, located in unpaved areas, in a 300 by 300 by 150 mm (12 by 12 by 6 inches) thick concrete slab set flush with adjacent finished grade. Where cleanout is in force main, provide a blind flange top connection. The center of the flange shall be equipped with a 50 mm (2 inches) base valve to allow the pressure in the line to be relieved prior to removal of the blind flange. Frames and covers for pressure (force) mains shall be 600 mm (24 inches) in diameter.
- B. The top of the cleanout assembly shall be 50 mm (2 inches) below the bottom of the cover to prevent loads being transferred from the frame and cover to the piping.

3.16 SETTING OF GATE VALVES:

- A. Avoid setting valves under pavement except where shown on the drawings.
- B. Clean valve interior before installation.

- C. Set valve plumb, restrain ends of valves when indicated on the drawing.
- D. Set valve box cover flush with the finished grade. Valve box shall be centered over the operating nut.

3.17 SETTING OF CHECK VALVES:

- A. Check valves shall be installed in a vault, direct burial of check valves shall not be permitted.
- B. Check valves shall be set in the horizontal position, with adequate clearance to the structure to allow for movement of the lever and maintenance of the valve.
- C. Clean the interior of the valve and check its operation prior to installation.
- D. After installation, adjust the weight on the lever to provide proper operation in accordance with the manufacturer's recommendations.

3.18 SETTING OF AIR RELEASE VALVES:

- A. Set valves in vault with adequate space for maintenance of the valve. The vault shall have a solid floor to prevent all sanitary blowoff from being absorbed into the soils.
- B. Valves shall be set plumb and supported to the vault. Maintain accessibility to the isolation valve on the air valve line.
- C. Install the valve after the completion of testing of the pressure (force) main.

3.19 INSPECTION OF SEWERS:

Inspect and obtain the Resident Engineer's approval. Thoroughly flush out before inspection.

Lamp test between structures and show full bore indicating sewer is true to line and grade. Lip at joints on the inside of gravity sewer lines are not acceptable.

3.20 TESTING OF SANITARY SEWERS:

- A. Gravity Sewers and Manholes (Select one of the following):
 - 1. Air Test: Vitrified Clay Pipe ASTM C828. PVC Pipe, Uni-Bell Uni-B-6. Clean and isolate the section of sewer line to be tested. Plug or cap the ends of all branches, laterals, tees, wyes, and stubs to be included in the test to prevent air leakage. The line shall be pressurized to 28 kPa (4 psi) and allowed to stabilize. After pressure stabilization, the pressure shall be dropped to 24 kPa (3.5 psi) greater than the average back-pressure of any groundwater above the sewer. The minimum test time shall be as specified in Uni-Bell Uni-B-6.
 - 2. Exfiltration Test:
 - a. Subject pipe to hydrostatic pressure produced by head of water at depth of 900 mm (3 feet) above invert of sewer at upper manhole under test. In areas where ground water exists, head of water shall be 900 mm (3 feet) above existing water table. Maintain head of water for one hour for full absorption by pipe body before testing. During one hour test period, measured maximum allowable rate of exfiltration for any section of sewer shall be 11 L (3.0 gallons) per hour per 30 m (100 feet).
 - b. If measurements indicate exfiltration is greater than maximum allowable leakage, take additional measurements until leaks are located. Repair and retest.

3. Infiltration Test: If ground water level is greater than 900 mm (3 feet) above invert of the upper manhole, infiltration tests are acceptable. Allowable leakage for this test will be the same as for the exfiltration test.
- B. Pressure (Force) Mains: Test at 690 kPa (100 psi) for two hours. Leakage shall be per the following:

$$L = J * D * \sqrt{P} / 4500$$

Where:

L = Maximum Allowable Leakage in Gallons per Hour

J = Number of Joints in Test Area

D = Diameter of Pipe in Inches

P = Average Test Pressure (Psi)

- C. Testing of Fiberglass Sewage Holding Tanks: No leakage at 35 kPa (5 psi) air pressure test with 5:1 safety factor. Test by Contractor after installation.
- D. Testing of Concrete Wet Well: No leakage with the wet well completely filled with water for a duration of 4 hours.

--- E N D ---

**SECTION 33 40 00
STORM DRAINAGE UTILITIES**

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies construction of outside, underground storm sewer systems. The storm sewer systems shall be complete and ready for operation, including all drainage structures, frames, grate and covers, connections to new buildings, structure service lines, existing storm sewer lines and existing drainage structures and all required incidentals.

1.2 RELATED WORK:

- A. Maintenance of Existing Utilities: Section 01 00 00, GENERAL REQUIREMENTS.
- B. Excavation, Trench Widths, Pipe Bedding, Backfill, Shoring, Sheeting, Bracing: Section 31 20 00, EARTH MOVING.
- C. Concrete Work, Reinforcing, Placement and Finishing: Section 03 30 00, CAST-IN-PLACE CONCRETE.
- D. Fabrication of Steel Ladders: Section 05 50 00, METAL FABRICATIONS.
- E. Protection of Materials and Equipment: Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 QUALITY ASSURANCE:

- A. Products Criteria:
 - 1. Multiple Units: When two or more units of the same type or class of materials or equipment are required, these units shall be products of one manufacturer.
 - 2. Nameplates: Nameplate bearing manufacturer's name, or identifiable trademark, securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped, or otherwise permanently marked on each item of equipment.
- B. Comply with the rules and regulations of the Public Utility having jurisdiction over the connection to public storm sewer lines and the extension, and/or modifications to Public Utility systems.

1.4 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturers' Literature and Data: Submit the following as one package:
 - 1. Piping.
 - 2. Jointing material.
 - 3. Manhole, inlet and catch basin material.
 - 4. Frames and covers.
 - 5. Steps.
 - 6. Resilient connectors and downspout boots.

C. One copy of State Department of Transportation standard details of MANHOLES, INLETS and catch basins.

D. One copy of State Department of Transportation specification.

1.5 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. American Society for Testing and Materials (ASTM):

A48-03/A48M-03..... Gray Iron Castings

A536-84(2004)..... Ductile Iron Castings

A615-05/A615M-05..... Deformed and Plain-Billet Steel Bars for Concrete Reinforcement

A655-04e1/A655M-04e1... Reinforced Concrete D-Load Culvert, Storm Drain and Sewer Pipe

A742-03/A742M-03..... Steel Sheet, Metallic Coated and Polymer Precoated for
Corrugated Steel Pipe

A760-01a/A760M-01a..... Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains

A762-00/A762M-00..... Corrugated Steel Pipe, Polymer Precoated for Sewers and
Drains

A798-01/M798M-01 Installing Factory-Made Corrugated Steel Pipe for Sewers and
Other Applications

A849-00 Post-Applied Coatings, Pavings, and Linings for Corrugated
Steel Sewer and Drainage Pipe

A929-01/A929M-01..... Steel Sheet, Metallic Coated by the Hot Dip Process for
Corrugated Steel Pipe

C76-05a/C76M-05a Reinforced Concrete Culvert, Storm Drain and Sewer Pipe

C139-03 Concrete Masonry Units for Construction of Catch Basins and
Manholes

C150-04ae1 Portland Cement

C443-05/C443M-05 Joints for Concrete Pipe and Manholes, Using Rubber Gaskets

C478-03a/C478M-03a Precast Reinforced Concrete Manhole Sections

C506-05/C506M-05 Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe

C507-05a/C507M-05a Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer
Pipe

C655-04e1/C655M-04e1 Reinforced Concrete D-Load Culvert, Storm Drain and Sewer
Pipe

C1433-04e1/C1433M-04e1 Precast Reinforced Concrete Box Sections for Culverts, Storm
Drains and Sewers

C828-03 Low-Pressure Air Test of Vitrified Clay Pipe Lines

C857-95(2001)	Minimum Structural Design Loading for Underground Precast Concrete Utility Structures
C923-02/C923M-02	Resilient Connectors between Reinforced Concrete Manhole Structures, Pipes and Materials
C924-02/C924M-02	Testing Concrete Pipe Sewer Lines by Low Pressure Air Test Method
C1103-03/C1103M-03	Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
D698-00ae1	Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft ³ (600 kN-m/m ³))
D1056-00	Flexible Cellular Materials-Sponge or Expanded Rubber
D2412-02	Determination of External Loading Characteristics of Plastic Pipe by Parallel Plate Loading
D2321-04e1	Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications .
D3034-04a	Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
D3212-96a(2003)e1	Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
D3350-04	Polyethylene Plastics Pipe and Fittings Materials
D4101-05a	Polypropylene Injection and Extrusion Materials
F477-02e1	Elastomeric Seals (Gaskets) for Joining Plastic Pipe
F679-03	Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
F714-05	Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
F794-03	Poly (Vinyl Chloride)(PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
F894-98a	Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe
F949-03	Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with Smooth Interior
F1417-92(2005)	Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air

NOTE: ASTM test methods shall be the current version as of the date of advertisement of the project.

- C. American Association of State Highway and Transportation Officials (AASHTO):
HB17

M190-04.....	Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches
M198-05.....	Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets
M294-04.....	Corrugated Polyethylene Pipe, 300-1500 mm (12 to 60 inches) Diameter

PART 2 - PRODUCTS

2.1 PIPING:

A. Gravity Lines (Pipe and Appurtenances):

1. Concrete:

- a. Reinforced pipe, ASTM C76. Class III or ASTM C655, 29.2kN/lm (2000 lbs/lf) per 300 mm (1 foot) inside dia. Reinforced arch culvert and storm drainpipe shall comply with ASTM C506, Class A-III. Reinforced elliptical culvert and storm drainpipe shall comply with ASTM C507, Class HE III. Joints shall be watertight flexible joints made with rubber-type gaskets conforming to ASTM C443.

2. Polyvinyl Chloride (PVC):

- a. Pipe and Fittings, Type PSM PVC Pipe, shall conform to ASTM D3034, Type PSM, SDR 35. Pipe and fittings shall have elastomeric gasket joints providing a watertight seal when tested in accordance with ASTM D 3212. Gaskets shall conform to ASTM F 477. Solvent welded joints shall not be permitted.
- b. Pipe and fittings, smooth wall, corrugated or ribbed PVC, shall conform to the following:
 - 1) Pipe and fittings shall conform to ASTM F949 corrugated sewer pipe with a smooth interior. The corrugated outer wall shall be fused to the smooth interwall at the corrugation valley. Pipe and fitting shall have a smooth bell, elastomeric joints conforming to ASTM D 3212, and shall have a minimum pipe stiffness of 345 kPa (50 psi) at 5 percent deflection, when tested in accordance with ASTM D 2412. Corrugation shall be perpendicular to the axis of the pipe to allow gaskets to be installed on field cut sections of pipe without the requirement for special fittings.
 - 2) Ribbed wall PVC pipe and fittings shall conform to ASTM F794, Series 46. Ribbed sewer pipe with smooth interior pipe and fittings shall have a smooth bell, elastomeric joints conforming to ASTM D 3212, and shall have a minimum pipe stiffness of 320 kPa (46 psi) when tested in accordance with ASTM D 2412, at 5 percent vertical deflection. Joints shall not leak at 7.6 m (25 feet) of head under 5 percent deflection.
 - 3) Solid wall pipe and fittings shall conform to ASTM F 679, SDR 26 pipe and fittings shall gaskets conforming to ASTM F 477, and shall be able to withstand a hydrostatic pressure of 345 kPa (50 psi).

3. High Density Polyethylene (HDPE):

- a. Smooth Wall PE Pipe: Shall comply with ASTM F714, DR 21 for pipes 75 to 600 mm (3 to 24 inches), and SDR 26 for pipes 650 to 1200 mm (26 to 48 inches). Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.
- b. Corrugated PE Pipe: Shall comply with AASHTO M294, for pipes 300 to 1500 mm (12 to 60 inches). Pipe walls shall have following minimum properties:

<u>Nominal Size</u>	<u>Minimum Wall Area</u>	<u>Min. Moment of Inertia mm⁴/mm (in⁴/in)</u>
300 mm (12 in)	3200 mm ² /m (1.50 in ² /ft)	390 (.024)
375 mm (15 in)	4000 mm ² /m (1.91 in ² /ft)	870 (.053)
450 mm (18 in)	4900 mm ² /m (2.34 in ² /ft)	1020 (.062)
600 mm (24 in)	6600 mm ² /m (3.14 in ² /ft)	1900 (.116)
750 mm (30 in)	8300 mm ² /m (3.92 in ² /ft)	2670 (.163)
900 mm (36 in)	9500 mm ² /m (4.50 in ² /ft)	3640 (.222)
1050 mm (42 in)	9900 mm ² /m (4.69 in ² /ft)	8900 (.543)
1200 mm (48 in)	10900 mm ² /m (5.15 in ² /ft)	8900 (.543)
1350 mm (54 in)	12000 mm ² /m (5.67 in ² /ft)	13110 (.800)
1500 mm (60 in)	13650 mm ² /m (6.45 in ² /ft)	13110 (.800)

- c. Profile Wall PE Pipe: Shall comply with ASTM F894, Class 160, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, Minimum cell class 334433C. Pipe walls shall have following minimum properties:

<u>Nominal Size</u>	<u>Minimum Wall Area</u>	<u>Min. Moment of Inertia mm⁴/mm (in⁴/in)</u>
450 mm (18 in)	6300 mm ² /m (2.96 in ² /ft)	850 (.052)
525 mm (21 in)	8800 mm ² /m (4.15 in ² /ft)	1150 (.070)
600 mm (24 in)	9900 mm ² /m (4.66 in ² /ft)	1330 (.081)
675 mm (27 in)	12500 mm ² /m (5.91 in ² /ft)	2050 (.125)
750 mm (30 in)	12500 mm ² /m (5.91 in ² /ft)	2050 (.125)
825 mm (33 in)	14800 mm ² /m (6.99 in ² /ft)	2640 (.161)
900 mm (36 in)	17100 mm ² /m (8.08 in ² /ft)	3310 (.202)

1050 mm (42 in)	16500 mm ² /m (7.81 in ² /ft)	4540 (.277)
1200 mm (48 in)	18700 mm ² /m (8.82 in ² /ft)	5540 (.338)

2.2 JOINTING MATERIAL:

- A. Concrete Pipe: Rubber gasket ASTM C443.
- B. Polyvinyl Chloride (PVC) Pipe:
 - 1. PVC Plastic Pipe: Joints shall comply with ASTM D3212, Elastomeric Gaskets shall comply with ASTM F477 and as recommended by the manufacturer.
- C. PE Plastic Pipe:
 - 1. Smooth Wall PE Plastic Pipe: Pipe shall be joined using butt fusion as recommended by the manufacturer.
 - 2. Corrugated PE Plastic Pipe: Water tight joints shall be made using a PVC or PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477. Soil tight joints shall conform to requirements in AASHTO HB-17, Division II, for soil tightness and shall be as recommended by the manufacturer.
 - 3. Profile Wall PE Plastic Pipe: Joints shall be gasket or thermal weld type with integral bell in accordance with ASTM F894.
- D. Corrugated Metal Pipe:
 - 1. Gaskets: Rubber gaskets, shall comply with ASTM D1056, Type 2 B3 Rubber O-rings shall conform to ASTM C443.
 - 2. Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of the band, and the size of the angles, bolts, rods and lugs as indicated, or where not indicated, as specified in the applicable standards or specifications for the pipe.

2.3 MANHOLES, INLETS AND CATCH BASINS:

- A. Manholes, inlets and catch basins shall be constructed of precast concrete segmental blocks, precast reinforced concrete rings, precast reinforced sections, or cast-in-place concrete. Manholes, inlets and catch basins shall be in accordance with State Department of Transportation standard details, and the following VA requirements, in case of variance, VA requirements supersede:
 - 1. Precast Concrete Segmental Blocks: Blocks shall conform to ASTM C139 and shall not be less than 150 mm (6 inches) thick for manholes to a depth of 3.6 m (12 feet); not less than 200 mm (8 inches) thick for manholes deeper than 3.6 m (12 feet) deep. Blocks shall be not less than 200 mm (8 inches) in length. Blocks shall be shaped so that joints seal and bond effectively with cement mortar. Parge structure interior and exterior with 15 mm (1/2 inch) of cement mortar applied with a trowel and finished to an even glazed surface.
 - 2. Precast Reinforced Concrete Rings: Rings or sections shall have an inside diameter as indicated on the drawings, and shall be not less than 1200 mm (48 inches) in diameter. Wall

- thickness shall conform to requirements of ASTM C76, except that lengths of the sections may be shorter as conditions require. Tops shall conform to ASTM C478. Top section shall be eccentric cone type. Steps on inside wall shall be in the same plane from bottom of structure to manhole cover.
3. Precast Reinforced Concrete Manhole Risers and Tops: Design, material and installation shall conform to requirements of ASTM C478. Top sections shall be eccentric. Steps on inside wall shall be in the same plane from bottom of structure to manhole cover.
 4. Flat top manhole tops shall be reinforced concrete as detailed on the drawings.
 5. Precast Catch Basins: Concrete for precast sections shall have a minimum compressive strength of 35 MPa (5,000 psi) at 28 days, ASTM A615, Grade 60 reinforcing steel, rated for AASHTO HS20-44 loading with 30 percent impact, and conform to ASTM C-857.
 6. Mortar:
 - a. Precast Concrete Segmental Block Structures: By volume, 1 part of Portland cement, 1/4 part lime hydrate, and 3 parts sand.
 - b. Precast Reinforced Concrete Ring and Riser Structures: By volume, 1 part of Portland cement and 2 parts sand. Water in mixture shall produce a stiff, workable mortar, but shall not exceed 21L (5-1/2 gallons) per sack of cement.
 7. Flexible sealing compound shall be packaged in extruded preformed shape, sized to completely fill the joint between precast sections, and form permanently flexible watertight seal. The sealing compound shall be non-shrink and meet AASHTO M-198B.
 8. Frames and covers shall be gray cast iron conforming to ASTM A48. The frame and cover shall be rated for HS20-44 loading, have a studded pattern on the cover, and the words "storm sewer". The studs and the lettering shall be raised 8 mm (5/16 inch). The cover shall be a minimum of 600 mm (24 inches) in diameter and shall have four 19 mm (3/4 inch) vent holes and two lifting slots. The bearing surface of the frame and cover shall be machine finished. The cover shall fit firmly on the frame without movement when subject to traffic.
 9. Manhole steps shall be polypropylene plastic coated on a No. 4 deformed rebar conforming to ASTM C478, Polypropylene shall conform to ASTM D4101. Steps shall be a minimum of 250 mm (10 inches) wide and project a minimum of 125 mm (5 inches) away from the wall. The top surface of the step shall have a studded non-slip surface. Steps shall be placed at 300 mm (12 inch) centers.
 10. Ladders, brackets and hardware shall be constructed of welded aluminum, rails shall be 9 mm (3/8 inch) by 63 mm (2-1/2 inches) spaced a minimum of 400 mm (16 inches) apart. Rungs shall be 35 mm (1-3/8 inches) in diameter and have a non-slip surface. Standoffs shall offset the ladder 180 mm (7 inches) from the wall. The ladder assembly shall be rated for a minimum of 2200 N (500 pounds).

- B. Prefabricated Corrugated Metal Manholes: Manholes shall be the type and design as indicated on the drawings and as recommended by the manufacturer.
- C. Prefabricated Plastic Manholes and Drain Basins: Plastic manholes and drain basins shall be as indicated on the drawings.
- D. Frame and Cover for Gratings: Frame and cover for gratings shall be in accordance with State Department of Transportation standard details. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the drawings.

2.4 HEADWALLS:

- A. Headwalls shall be cast-in-place concrete and in accordance with State Department of Transportation standard details. Concrete shall have a minimum compressive strength of 20 MPa (3000 psi) at 28 days. The cement shall be Type III conforming to ASTM C150. Concrete shall conform with the provisions of Division 03 of these specifications.

2.5 CONCRETE:

Concrete shall be in accordance with Texas State Department of Transportation standard specification Item 360 – Class P. For concrete not specified in above standards, concrete shall have a minimum compressive strength of 20 MPa (3000 psi) at 28 days. The cement shall be Type III conforming to ASTM C150. Concrete shall conform to the provisions of Division 03 of these specifications.

2.6 REINFORCING STEEL:

Reinforcing steel shall be deformed bars, ASTM A615, Grade 40 unless otherwise noted.

2.7 FLARED END SECTIONS:

Flared End Sections: Sections shall be of standard design fabricated from zinc-coated steel sheets conforming to requirements of ASTM A929.

2.8 PRECAST REINFORCED CONCRETE BOX.

Precast Reinforced Concrete Box: For highway loadings with 600 mm (2 feet) of cover or more subjected to dead load only, conform to ASTM C1433; For less than 600 mm (2 feet) of cover subjected to highway loading, conform to ASTM C1433.

2.9 RESILIENT CONNECTORS AND DOWNSPOUT BOOTS:

- A. Resilient Connectors: Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923.
- B. Downspout Boots: Boots used to connect exterior downspouts to the storm drainage system shall be of gray cast iron conforming to ASTM A48, Class 30B or 35B.

2.10 WARNING TAPE:

Standard, 4-Mil polyethylene 76 mm (3 inch) wide tape detectable type, purple with black letters, and imprinted with "CAUTION BURIED STORM SEWER BELOW".

PART 3 - EXECUTION

3.1 EXCAVATION FOR STORM DRAINS AND DRAINAGE STRUCTURES:

Excavation of trenches and for appurtenances and backfilling for storm drains, shall be in accordance with the applicable portions of Section 31 20 00, EARTH MOVING.

3.2 PIPE BEDDING:

The bedding surface of the pipe shall provide a firm foundation of uniform density throughout the entire length of pipe. Concrete pipe requirements are such that when no bedding class is specified, concrete pipe shall be bedded in a soil foundation accurately shaped and rounded to conform with the lowest one-fourth of the outside portion of circular pipe. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall not be more than the length, depth, and width required for properly making the particular type of joint. Plastic pipe bedding requirements shall meet the requirements of ASTM D2321. Bedding, haunching and initial backfill shall be either Class IB or Class II material. Corrugated metal pipe bedding requirements shall conform to ASTM A798.

3.3 GENERAL PIPING INSTALLATION:

- A. Lay pipes true to line and grade. Gravity flow sewer shall be laid with bells facing upgrade.
- B. Do not lay pipe on unstable material, in wet trench or when trench and weather conditions are unsuitable for the work.
- C. Support pipe on compacted bedding material. Excavate bell holes only large enough to properly make the joint.
- D. Inspect pipes and fittings, for defects before installation. Defective materials shall be plainly marked and removed from the site. Cut pipe shall have smooth regular ends at right angles to axis of pipe.
- E. Clean interior of all pipe thoroughly before installation. When work is not in progress, open ends of pipe shall be closed securely to prevent entrance of storm water, dirt or other substances.
- F. Lower pipe into trench carefully and bring to proper line, grade, and joint. After jointing, interior of each pipe shall be thoroughly wiped or swabbed to remove any dirt, trash or excess jointing materials.
- G. Do not lay sewer pipe in same trench with another pipe or other utility.
- H. Do not walk on pipe in trenches until covered by layers of shading to a depth of 300 mm (12 inches) over the crown of the pipe.
- I. Install gravity sewer line in accordance with the provisions of these specifications and the following standards:
 - 1. Reinforced Concrete Pipe: Comply with manufacturer's recommendations with gasketed joints.
 - 2. Polyvinyl Chloride (PVC) Piping: ASTM D2321.

3. High Density Polyethylene (HDPE) Piping: Comply with manufacturer's recommendations with gasketed joints
4. Corrugated Metal Pipe: ASTM A798.

J. Warning tape shall be continuously placed 300 mm (12 inches) above storm sewer piping.

3.4 REGRADING:

- A. Raise or lower existing manholes and structures frames and covers in regraded areas to finish grade. Carefully remove, clean and salvage cast iron frames and covers. Adjust the elevation of the top of the manhole or structure as detailed on the drawings. Reset cast iron frame and cover, grouting below and around the frame. Install concrete collar around reset frame and cover as specified for new construction.
- B. During periods when work is progressing on adjusting manholes or structures cover elevations, the Contractor shall install a temporary cover above the bench of the structure or manhole. The temporary cover shall be installed above the high flow elevation within the structure, and shall prevent debris from entering the wastewater stream.
- C. The Contractor shall comply with all OSHA confined space requirements when working within existing structures.

3.5 CONNECTIONS TO EXISTING VA-OWNED MANHOLES:

Make pipe connections and alterations to existing manholes so that finished work will conform as nearly as practicable to the applicable requirements specified for new manholes, including concrete and masonry work, cutting, and shaping.

3.7 MANHOLES, INLETS AND CATCH BASINS:

- A. General:
 1. Circular Structures:
 - a. Precast concrete segmental blocks shall lay true and plumb. All horizontal and vertical joints shall be completely filled with mortar. Parge interior and exterior of structure with 15 mm (1/2 inch) or cement mortar applied with a trowel and finished to an even glazed surface.
 - b. Precast reinforced concrete rings shall be installed true and plumb. The joints between rings and between rings and the base and top shall be sealed with a preform flexible gasket material specifically manufactured for this type of application. Adjust the length of the rings so that the eccentric conical top section will be at the required elevation. Cutting the conical top section is not acceptable.
 - c. Precast reinforced concrete manhole risers and tops. Install as specified for precast reinforced concrete rings.
 2. Rectangular Structures:
 - a. Reinforced concrete structures shall be installed in accordance with Division 03, CONCRETE of these specifications.

- b. Precast concrete structures shall be placed on a 200 mm (8 inch) reinforced concrete pad, or be provided with a precast concrete base section. Structures provided with a base section shall be set on a 200 mm (8 inches) thick aggregate base course compacted to a minimum of 95 percent of the maximum density as determined by ASTM D 698. Set precast section true and plumb. Seal all joints with preform flexible gasket material.
3. Do not build structures when air temperature is 0 degrees C (32 degrees F), or below.
4. Invert channels shall be smooth and semicircular in shape conforming to inside of adjacent sewer section. Make changes in direction of flow with a smooth curve of as large a radius as size of structure will permit. Make changes in size and grade of channels gradually and evenly. Construct invert channels by one of the listed methods:
 - a. Forming directly in concrete base of structure.
 - b. Building up with brick and mortar.
5. Floor of structure outside the channels shall be smooth and slope toward channels not less than 1:12 (25mm per 300mm, 1-inch per foot) nor more than 1:6 (50mm per 300mm, 2 inches per foot). Bottom slab and benches shall be concrete.
6. The wall that supports access rungs or ladder shall be 90 degrees vertical from the floor of structure to manhole cover.
7. Install steps and ladders per the manufacturer's recommendations. Steps and ladders shall not move or flex when used. All loose steps and ladders shall be replaced by the Contractor.
8. Install manhole frames and covers on a mortar bed, and flush with the finish pavement. Frames and covers shall not move when subject to vehicular traffic. Install a concrete collar around the frame to protect the frame from moving until the adjacent pavement is placed. In unpaved areas, the rim elevation shall be 50 mm (2 inches) above the adjacent finish grade. Install a 200 mm (8 inches) thick, by 300 mm (12 inches) concrete collar around the perimeter of the frame. Slope the top of the collar away from the frame.

3.8 CURB INLETS, CATCH BASINS, AND AREA DRAINS:

Reinforced concrete as shown or precast concrete.

3.9 INSPECTION OF SEWERS:

Inspect and obtain the Resident Engineer's approval. Thoroughly flush out before inspection. Lamp between structures and show full bore indicating sewer is true to line and grade. Lip at joints on inside of sewer is prohibited.

3.10 TESTING OF STORM SEWERS:

- A. Gravity Sewers (Select one of the following):
 1. Air Test: Concrete Pipes conform to ASTM C924, Plastic Pipes conform to ASTM F1417, all other pipe material conform to ASTM C828 or C924, after consulting with pipe manufacturer. Testing of individual joints shall conform to ASTM C1103.

2. Exfiltration Test:

- a. Subject pipe to hydrostatic pressure produced by head of water at depth of 900 mm (3 feet) above invert of sewer at upper manhole under test. In areas where ground water exists, head of water shall be 900 mm (3 feet) above existing water table. Maintain head of water for one hour for full absorption by pipe body before testing. During 1 hour test period, measured maximum allowable rate of exfiltration for any section of sewer shall be 11L (3.0 gallons) per hour per 30 m (100 feet).
- b. If measurements indicate exfiltration is greater than maximum allowable leakage, take additional measurements until leaks are located. Repair and retest.

--- E N D ---

**SECTION 33 51 00
NATURAL-GAS DISTRIBUTION**

PART 1 - GENERAL

1.1 DESCRIPTION:

Outside underground gas distribution system for natural gas, complete, ready for operation, including cathodic protection if required, all appurtenant structures, and connections to new building structures and to existing gas supply. This specification does not apply to LPG distribution systems.

1.2 RELATED WORK:

- A. Maintenance of Existing Utilities: Section 01 00 00, GENERAL REQUIREMENTS.
- B. Excavation, Trench Widths, Pipe Bedding, Backfill, Shoring, Sheeting, Bracing: Section 31 20 00, EARTH MOVING.
- C. Section 03 30 00, CAST-IN-PLACE CONCRETE.

1.3 DEFINITIONS:

- A. Gas Main or Distribution Main: A distribution line that serves as a common source of supply for more than one service line.
- B. Gas Service Line: A distribution line that transports gas from a common source of supply to the meter set assembly.

1.4 QUALITY ASSURANCE:

- A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers, and will be based upon submission by Contractor for certification that:
 - 1. Manufacturers regularly and currently manufacture earthquake automatic gas shutoff valves, gas filters, regulators, and meters.
 - 2. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory and efficient operation on at least three installations for approximately 3 years. If elements of equipment lack a substantial experience record, such lack shall be brought to the attention of the Contracting Officer at the time of submission of shop drawings, with full information included to permit proper evaluation. Experience qualification shall be certified and a list of installations shall be furnished for earthquake automatic gas shutoff valves, gas filters, regulators, and meters.
- B. Apply and install materials, equipment, and specialties in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the Resident Engineer (RE) or Contracting Officers Technical Representative (COTR) for resolution. Provide copies of installation instructions to the RE or COTR prior to commencing installation of any item.
- C. All equipment shall be free from defects which would adversely affect the performance, maintainability and appearance of individual components or overall assembly.

- D. Assembly of Plastic Piping: Installation personnel shall have been trained, tested and certified under a procedure approved by the manufacturer of the piping. Proof of certification, in writing, shall be provided to the COTR or RE.
- E. Contractor shall conform to applicable local codes, American Society of Mechanical Engineers Gas Transmission and Distribution Piping Systems, publications of the Underwriters' Laboratories, Inc., National Fire Protection Association, Federal Specifications, American Society of Testing Materials, and current safety standards, all as defined in the Article of the Specifications relating to Applicable Publications.
- F. Comply with rules and regulations of the local utility having jurisdiction in all cases where gas lines are connected to public Utility Services.

1.5 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Piping:
 - 1. ASTM Compliance.
 - 2. Grade, class or type, schedule number.
 - 3. Manufacturer's Certification of Compliance with specified standards.
- C. Pipe Coatings:
 - 1. Manufacturer's Certification of Compliance with specified standards.
 - 2. Federal Specification Compliance.
- D. Pipe Fittings and Flanges:
 - 1. ASTM Compliance.
 - 2. Grade, class or type, schedule number.
 - 3. Catalog Cuts.
 - 4. Pressure and Temperature Rating.
- E. Manual Valves:
 - 1. Type and service.
 - 2. Catalog Cuts.
 - 3. Pressure and Temperature Ratings.
- F. Earthquake Automatic Gas Shut-off:
 - 1. UL Listing and ANSI Compliance.
 - 2. Certification of ASCE 25-97 Compliance.
 - 3. Pressure and Temperature Ratings.
 - 4. Pressure Loss and Flow Rate Data.
- G. Valve Boxes:
 - 1. Catalog Cuts.
- H. Gas Filter:

1. Catalog Cuts.
2. Removal Efficiency, Pressure and Temperature Rating.
- I. Gas Pressure Regulator:
 1. UL Listing.
 2. Pressure and Temperature Rating.
 3. Flow Capacities.
 4. Catalog Cuts.
- J. Meter:
 1. ANSI Compliance.
 2. Pressure and Temperature Rating.
 3. Certification of Compliance with local utility requirements.
- K. Certificate to indicate compliance with pressure tests on gas system.

1.6 APPLICABLE PUBLICATIONS:

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Federal Specifications (Fed. Spec.):
 - L-C-530C Coating, Pipe, Thermoplastic Resin
 - L-T-1512A Tape, Pressure Sensitive Adhesive, Pipe Wrapping
 - WWP-521 Malleable-Iron Threaded Fittings
 - WW-U-531 Unions
- C. American National Standards Institute (ANSI):
 - B1.20.1 Malleable-Iron Threaded Fittings: Threads
 - B16.3-98 Malleable-Iron Threaded Fittings: Dimensions and Pressure Rating
 - B16.5-03 Pipe Flanges and Flanged Fittings, NPS 1/2 Through NPS 24
 - B16.9-03 Factory-Made Wrought Steel Butt welding Fittings
 - B16.11-01 Forged Steel Fittings, Socket-Welding and Threaded
 - B16.34-97 Valves-Flanged, Threaded, and Welding End
 - B16.40-94 Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems
 - B31.8-95 Gas Transmission and Distribution Piping Systems
 - B109.2-92 Diaphragm Type Gas Displacement Meters
- D. American Petroleum Institute (API):
 - API Spec 6D-94 Pipeline Valves (Gate, Plug, Ball, and Check Valves)
- E. American Society for Civil Engineers (ASCE):
 - 25-97 Earthquake Actuated Automatic Gas Shutoff
- F. American Society for Testing and Materials (ASTM):
 - A197 Malleable Threaded Fittings, classes 150 and 300, and Unions.
 - A53M-04a Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
 - A126-04 Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - D450-00e1 Coal-Tar Pitch Used in Roofing, Dampproofing and Waterproofing
 - D2513-03 Thermoplastic Gas Pressure Pipe, Tubing, and Fittings

PART 2 - PRODUCTS

2.1 PIPE:

- A. Black Steel: Seamless or ERW, ASTM A53, Grade B, Schedule 40.
 - 1. Shop-applied pipe coating shall be one of the following types:
 - a. Coal Tar Enamel Coating: Exterior of pipe and fittings shall be cleaned, primed with Type B primer and coated with hot-applied coal-tar enamel with bonded layer of felt wrap in accordance with AWWA C203. Asbestos felt shall not be used; felt material shall be fibrous-glass mat as specified in Appendix Sec. A2.1 of AWWA C203.
 - b. Adhesive-Thermoplastic Resin Coating: Fed. Spec. L-C-530, Type I.
 - c. Adhesive-thermosetting Resin Coating: Fed. Spec. L-C-530, Type II.
 - 2. Field-applied plastic tape material for use on pipe joints and for repairing damaged areas of shop-applied coatings shall conform to Fed. Spec. L-T-1512, Type I, 250 μm (10 mils) nominal thickness for pipe joints, and Type II, 500 μm (20 mils) nominal thickness for coating repairs.
- B. Polyethylene Pipe: Pipe and tubing shall conform to ASTM D3350 AND ASTM D2513, pipe designations PE 2406 and PE 3408, rated SDR 11. Minimum wall thickness shall conform to ANSI/ASME B31.8. PE pipe is for underground use only. Polyethylene pipe shall be marked "GAS" and it is not be used where gas pressures are above 690 kPa (100 psi) or with operating temperatures below 7 degrees C (20 degrees F) or above 60 degrees C (140 degrees F).
- C. Fiberglass pipe shall conform to ASTM D2517. Pipe sections shall be marked "GAS" and as required by ASTM D2517. Minimum wall thickness shall be based on B31.8. Fiberglass pipe shall not be used where gas pressures are above 690 kPa (100 psi) or with operating temperatures below 29 degrees C (-20 degrees F) or above 66 degrees C (150 degrees F).

2.2 FITTINGS:

- A. Steel Pipe:
 - 1. Butt weld fittings shall be wrought steel, ANSI B16.9.
 - 2. Socket weld fittings shall be forged steel, 13.8 MPa (2000 Psi class), ANSI B16.11.
 - 3. Threaded fittings shall be malleable iron, ANSI 16.3 or forged steel, ANSI B16.11.
 - 4. Flanges shall be steel, Class 150, ANSI B16.5.
- B. Polyethylene Plastic Pipe Fittings: ASTM D2513.
- C. Fiberglass: Shall conform to ASTM D2517.

2.3 JOINTS:

- A. Socket or butt welded for steel pipe, ANSI B31.8. Threaded joints not permitted except at valve connections.
- B. Polyethylene pipe joints shall be heat fusion, either butt fusion or socket fusion.
- C. Fiberglass joints and adhesive shall conform to ASTM D2517.

2.4 VALVES:

All types of valves shall be accessible, labeled and specified for use for controlling multiple systems.

- A. Manual: Valves shall be suitable for shutoff or isolation service.

1. Lubricated plug type for gas service shall be cast iron, semi-steel or cast steel. Valves shall have capacity to operate in lines with 690 kPa (100 psi) working pressure. Steel valves 40 mm (1-1/2 inches) and smaller installed underground and shall conform to ASME B16.34, carbon steel, socket weld ends. Steel valves 40 mm (1-1/2 inches) and smaller, installed above ground, shall conform to ASME B16.34, carbon steel, socket weld or threaded ends. Steel valves 50 mm (2 inches) and larger shall conform to API spec 6D, carbon steel, butt weld ends, Class [] for underground installations. Above ground steel valves 50 mm (2 inches or larger) shall conform to API Spec 6D, carbon steel, butt weld or flanged ends, Class []. Cast iron valves shall conform to ASTM A126, Class B, Type 301 or 302, as specified in Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
 - a. Underground: 50 mm (2 inch) nut for socket wrench operation.
 - b. Above Ground and In Pits: Lever operation, locking type. Provide one lever for each valve.

B. Polyethylene Valves:

1. Valves shall conform to ASME B16.40. Polyethylene valves, in sizes 15 mm to 150 mm (1/2 inch to 6 inches) may be used with polyethylene distribution and service lines, in lieu of steel valves, for underground installation only.

2.5 VALVE BOXES:

- A. Cast iron extension box with screw or slide type adjustment and flared base. Minimum thickness of metal, 5 mm (3/16 inch). Box shall be of such length as can be adapted, without full extension, to depth of cover required over pipe at valve location.
- B. Cast the word "GAS" in cover.
- C. Provide 4 "T" handle socket wrenches of 16 mm (5/8 inch) round stock long enough to extend 600 mm (2 feet) above top of deepest valve box.
- D. Provide box with heavy coat of bituminous paint.

2.6 PIPE SLEEVES:

Ductile iron or coated steel.

2.7 GAS FILTER:

- A. Replaceable glass-fiber or cellulose cartridge with 10 micron particle retention. Filter enclosure shall be pipe size of the regulator or larger as required by pressure drop considerations. Lockup pressure of the supply service will be (Kpa) (Psi).
- B. Plug all drains or instrumentation outlets. Provide vent with cock for relieving pressure in filter.

2.8 GAS PRESSURE REGULATORS:

Pressure regulators for individual service lines shall be capable of reducing distribution line pressure to pressures required for users. Ferrous bodies. Pressure relief shall be set at a lower pressure than would cause unsafe operation of any connected user. Gas valve shall be installed

immediately upstream of each pressure regulator and regulator shall have a single port with orifice diameter no greater than that recommended by manufacturer for the maximum gas pressure at the regulator inlet. Regulator vent valve shall be of resilient materials designed to withstand flow conditions when pressed against valve port. Regulator shall be capable of limiting build-up of pressure under no-flow conditions to 50 percent or less of the discharge pressure maintained under flow conditions. Contractor shall demonstrate to COTR that the regulator does not leak after final inspection.

2.9 METERS:

- A. Gas meters shall be of type approved by local gas Utility as specified herein.
- B. Meters shall comply with ANSI B109.2. Meters shall be pedestal mounted. Meters shall be provided with over-pressure protection as specified in ASME B31.8, tamper-proof protection, frost protection, fungus-proof protection. Meters shall be suitable for accurately measuring and handling gas at pressures, temperatures, and flow rates indicated. Meters shall have a pulse switch initiator capable of operating up to speeds of 500 pulses per minute. Meters shall be protected from any damage.

2.10 WARNING TAPE:

Standard, 4-Mil polyethylene 76 mm (3 inch) wide tape, detectable type, yellow with black letters, and imprinted with "CAUTION BURIED GAS LINE BELOW".

PART 3 - EXECUTION

3.1 GAS MAINS:

Pipe for gas mains shall be polyethylene. Steel pipe and fittings shall be coated with protective covering as specified. Polyethylene mains shall not be installed above ground.

3.2 BUILDING SERVICE LINES:

- A. Install gas service lines to point of connection within approximately 1500 mm (5 feet) outside of buildings to which such service is to be connected and make connections thereto. The point of delivery is the meter set assembly.
- B. Where building services have not been installed, provide temporary caps.
- C. Connect service lines to top of mains by two-strap service clamp or coupling (socket) welded to main and into which is screwed a street tee and street elbow swing, joint assembly.
- D. The service lines shall be as short and as straight as practicable between the point of delivery and the gas main and shall not be bent or curved laterally unless necessary to avoid obstructions or otherwise permitted. Service lines shall be laid with as few as joints as practicable using standard lengths of pipe. Polyethylene or fiberglass service lines shall not be installed aboveground except as permitted in ANSI B31.8.

3.3 PIPE INSTALLATION, GENERAL:

- A. Gas distribution system and equipment shall be installed in accordance with the manufacturer's recommendations and applicable sections of B31.8 and NFPA 54.
- B. Excavation and backfilling shall be as specified in Section 31 20 00, EARTH MOVING.
- C. Heating trenches, storm and sanitary sewer lines, and water mains shall have right of way.
- D. Warning tape shall be continuously placed 300 mm (12 inches) above buried gas lines.
- E. Make service connections at the top of the main, whenever the depth of the main is sufficient to allow top connections. When service connections cannot be made at the top of the main, they shall be made on the side of the main as close to the top as possible. Service connections shall not be made lower than the horizontal midpoint of the gas main.
- F. Before entering building, underground service line shall rise above grade close to building to permit possible gas leaks to vent themselves.
- G. Main services and main service shut off valves shall have a 600 mm (24 inch) minimum cover or as recommended by local utility.
- H. Service lines shall have a 450 mm (18 inch) minimum cover or as recommended by local utility.
- I. Where indicated, the main shall be concrete-encased. Non-metallic pipe to be concrete encased shall be sleeved as indicated. The sleeve shall be sloped and vented to atmosphere at the highest point or where shown.
- J. Connections between metallic and plastic piping shall be made only outside, underground, and with approved transition fittings.

3.4 NON-METALLIC PIPE INSTALLATION:

- A. Install pipe in trench in accordance with recommendations of the pipe manufacturer. Provide sufficient slack to allow for expansion and contraction.
- B. Joints: Fusion welds shall be made in accordance with the recommendations of the polyethylene pipe manufacturer. Adhesive joints for fiberglass plastic pipe shall be made in accordance with manufacturer's recommendations.
- C. All offsets in piping shall be made with manufactured fittings. Bending of piping to form offsets shall not be permitted.
- D. Connections between plastic pipe and metal pipe shall be made in accordance with recommendations of the pipe manufacturer.
- E. Copper Tracer Wire: Copper tracer wires consisting of No. 14 AWG solid, single conductor, insulated copper wire shall be installed in the trench with all piping to permit location of the pipe with electronic detectors. The wire shall not be spiraled around the pipe nor taped to the pipe. Wire connections are to be made by stripping the insulation from the wire and soldering with rosin core solder. Solder joints shall be wrapped with rubber tape and electrical tape. At least every 300 m (1000 feet), provide a 2.3 kg (5 pound) magnesium anode attached to the main tracer wire by solder joint shall be wrapped with rubber tape and with electrical tape. An anode shall be attached at the end of each line.

3.5 APPLICATION OF PLASTIC TAPE:

- A. Field apply plastic tape to steel pipe joints and damaged areas of coatings after pressure tests.
- B. Clean and free of burrs and rust, joint areas before taping. Damaged coating shall be smoothed down or cut away if not firmly bonded to the pipe.
- C. Wrap spirally with a two-layer wrapping system, overlapping the coating surface at least 75 mm (3 inches). Initially stretch tape sufficiently to conform to the surface to which it is applied, using one layer half-lapped for tape 50 mm (2 inches) or less in width, or one layer lapped at least 25 mm (1 inch) for tape more than 50 mm (2 inches) wide.
- D. A second layer lapped as above, with a tension as it comes off the roll shall then be applied and pressed to conform to the shape of the component.

3.6 SETTING VALVES:

- A. Do not install valves under pavement unless shown on drawings.
- B. Clean valve interior before installation.

3.7 VALVE BOXES:

- A. Set cover flush with finished grade.
- B. Protect boxes located in roadway against movement by a concrete slab at least 900 mm (3 foot) square by 150 mm (6 inches) deep.
- C. Set other valve boxes with a concrete slab 450 mm (18 inches) by 450 mm (18 inches) by 150 mm (6 inches) deep and set flush with grade.
- D. All exposed portions of valve boxes shall be painted "Traffic Yellow."

3.8 PIPE SLEEVES:

- A. Pipe shall be continuous through sleeves. Set sleeves in place before concrete is poured.
- B. Seal between sleeve/core opening and the pipe with modular mechanical type link seal.
- C. Provide where gas lines pass through retaining walls, foundation walls or floors. Split sleeves may be installed where existing lines pass thru new construction.

3.9 DRIPS:

- A. Drips shall be provided where indicated or as a minimum where piping turns from a horizontal run to a vertical rise. Drips shall conform to the detail shown or may be of commercial units of approved type and capacity.
- B. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.

3.10 PIPE CLEANING:

- A. All pipe sections shall be blown down with 690 kPa (100 psi) air to remove all sand, soil and debris.
- B. Blow down procedure shall be done after system is complete, but before valves are installed.

3.11 FILTER, PRESSURE REGULATOR AND METER INSTALLATION:

Filter, pressure regulator and meter installation shall be installed per manufacturer's recommendations and per NFPA 54.

3.12 CATHODIC PROTECTION:

- A. Where soil resistivity is less than 4000 ohm-cm or when required by gas utility, Section 26 42 00, CATHODIC PROTECTION is required.
- B. Buried metallic gas pipe, fittings, and accessories shall be shop coated as previously specified and cathodically protected (furnish cathodic protection test kit.)
- C. Valves and other metallic components installed on buried plastic piping shall be shop coated and cathodically protected (furnish cathodic test kit.)
- D. Installation of Anodes:
 - 1. Place anodes into augured holes by grasping the cloth gathered at top of packaged anode.
 - 2. Replace ruptured anode packages with undamaged ones. Under no circumstances lower anode into hole by lead wire alone.
 - 3. Presoak packaged anodes in water for at least 15 minutes prior to installation. Pour a minimum of 11 L (3 gallons) of water over anode after it has been positioned in the augured hole.
 - 4. Tamp fine dirt or paddled around anode to insure contact between anode and native earth.
 - 5. Adequate slack in the lead wire to preclude tearing lead wire loose during backfilling and compacting procedures.
 - 6. Locate anodes so that minimum distance of 920 mm (36 inches) is maintained between anode and structures to which it is to be attached.
 - 7. Connect lead wire to piping by using the thermite welding process.
 - 8. Connection shall be waterproofed by use of cold applied, coal-tar pitch conforming to ASTM D450, and then covered by a pipeline felt or similar patch prior to backfilling.
- D. Test Stations:
 - 1. Provide a test station for each 10 anodes to permit testing for performance of the cathodic protection system. Use No. 12 stranded copper wire, TW covered, connected to the pipe by the termite welding process.
 - 2. Make connections waterproof by application of coal tar pitch conforming to ASTM D450.
 - 3. Leave adequate slack in the test leads to assure that the test leads will not be torn loose during backfill or compacting operations.

3.13 TESTS:

- A. Piping System: Inspection, testing and purging shall be in accordance with NFPA 54 and B31.8. Maximum working pressure will be ____ kPa (____psi).
- B. Cathodic Protection System:
 - 1. Testing of Anodes: Prior to connecting anode lead wire to the piping, insert a millimeter in the circuit and measure and record current output of each anode. When maximum current

outputs, as set below, for the different sizes of anodes are exceeded, insert nickel chromium resistance wire in the circuit to reduce current output to maximum allowable for a given size anode. Resistance wire connections to anode lead wires shall be accomplished with silver solder and soldered joints wrapped with a minimum of three layers of high dielectric strength electrical tape. Cover with rubber all nickel chromium resistance wire. Maximum allowable current outputs for the different size anodes to allow for design life are as follows:

Weight (Bare Anodes)	Allowable Current Output
2.3 kg (5 lb) Anode	10 Milliamperes
4 kg (9 lb) Anode	20 Milliamperes
7.7 kg (17 lb) Anode	40 Milliamperes
14.5 kg (32 lb) Anode	75 Milliamperes

2. Final Test: Final test of the cathodic protection system shall include measuring pipe-to-soil potentials over the entire system. Make potential measurements with potentiometer voltmeter (minimum internal resistance of 50,000 ohms per volt) and a copper/copper sulfate reference electrode placed at the finished grade level and directly over the pipe. Adequate number of measurements shall be taken over the extent of piping to insure that a minimum potential value of -0.85 volts exists over all new gas piping. Upon completion of testing, a report setting forth potential values acquired by location shall be submitted to the Government.

--- E N D ---

SECTION 33 63 00
STEAM ENERGY DISTRIBUTION

PART 1 GENERAL

1.01 DESCRIPTION

- A. Underground steam distribution and condensate return piping system, including manholes. Type of system shall be walk-through concrete tunnels with short sections of pre-engineered direct-buried drainable-dryable-testable (DDT) to connect to existing pipe outside of the tunnel.

1.02 DEFINITIONS

- A. System: A complete underground steam and condensate distribution system including all components such as carrier piping, pipe supports, insulation, protective enclosures, anchors, corrosion protection and accessories.
- B. Pre-Engineered Direct-Buried System: System that is designed and factory-fabricated by a company specializing in these systems. The system includes pre-fabricated protective enclosures and does not require a concrete trench or tunnel. The pre-engineered system shall include all piping and components to a point at least 150 mm (6 inches) inside the building and manhole walls.
- C. Drainable-Dryable-Testable (DDT) Pre-Engineered Direct-Buried System: A factory-fabricated system including an airtight and watertight outer protective casing, an insulated carrier pipe and an air space between the insulated carrier pipe and the casing. Drains and vents are provided in the ends of the system (in manholes or buildings). The drains allow draining of ground water or condensate that may leak into the air space if there is a failure in the casing or the carrier pipe. The vents allow water vapor to escape and provide an indication of leakage.
- D. Water-Spread-Limiting (WSL) Pre-Engineered Direct-Buried System: A factory-fabricated system including an airtight and watertight outer protective casing and an insulated carrier pipe. It is fabricated in short sections (approximately 6 m (20 feet) long) which are independent from each other in that ground water or condensate which leaks from or into one section cannot travel into the next section. Field-assembly of the sections requires no welding as the sections push together with a system of couplings and seals. Thermal expansion is absorbed in the clearance between carrier pipe ends in the couplings so that no expansion loops are required.
- E. Walk-through Concrete Tunnels: System located below grade with sufficient space for carrier pipes, other services, and space to walk upright along the entire length of the system. Designed by project engineer and field erected. Prefabricated concrete tunnel sections may be used.
- F. Carrier Pipe: Pipe carrying the steam or condensate.
- G. Casing: Outer protective pipe on pre-engineered systems. Carrier pipe and insulation are within the casing. The casing may also be referenced as the "conduit."
- H. Project Drawings: The "MS" project Drawings accompanying this specification provide information on:
 - 1. The size of carrier pipes, approximate length, and site location of the system.

2. The elevation and routing of the piping on the site.
3. Location and design of manholes and piping therein.
4. The obstacles located within approximately 25 m (8 feet) of the centerline of the system, including crossing utilities, that must be avoided or altered.
5. Type of system required - walk-through tunnel, pre-engineered direct-buried.
6. Location of piping anchors.
7. Operating pressure and temperature of systems.

Details applicable to type of system specified.

9. Details of manhole and building entrances.
10. Other pertinent general information.

J. Pressures: Pressures listed in this section are gauge pressure unless otherwise noted.

1.03 RELATED WORK

- A. Section 01 00 00 – General Requirements: Phasing of work.
- B. Section 31 20 00 – Earth Moving: Excavation, shoring and backfill.
- C. Section 03 30 00 – Cast-In-Place Concrete: Concrete work.

1.04 QUALITY ASSURANCE

- A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers.
- B. For pre-engineered direct-buried systems, expansion joints and ball joints, submit certification that:
 1. Manufacturers regularly and currently manufacture the product.
 2. There is a permanent service organization trained by the manufacturer that will provide the required field supervision of the installation of the system or equipment. Submit name and address of the service organization.
- C. The manufacturer of pre-engineered direct-buried distribution system shall design the system to comply with the requirements of these specifications and is responsible for the complete product to be supplied, fabrication, witnessing installation and testing of the system. The complete design of the system shall be prepared, signed and sealed by a Professional Engineer employed by the system manufacturer.
- D. Products Experience Record:
 1. Pre-Engineered Direct-Buried Systems: Shall be manufactured by a company which specializes in these systems and which has been in this business for five or more years.

2. All Other Products: The designs shall be of current production and have been in satisfactory operation on at least three installations for approximately five years.
- E. Provide a complete installation with all necessary specialties, materials and equipment fully and properly connected and coordinated. Installation shall be fully operational upon completion of work defined and as phased.
- F. Apply and install systems, materials, equipment and specialties in accordance with manufacturer's instructions. Printed instructions shall be available at the site prior to and during construction.
- G. Materials, design, installation and workmanship shall conform to applicable local codes, and to national codes and standards as referenced in this specification.
- H. Manufactured Products:
 1. When two or more items serve the same function, they shall be products of one manufacturer.
 2. Manufacturers of assemblies of products, which include components made by others, shall assume complete responsibility for final assembled unit.
 - a. All components of an assembled unit need not be products of the same manufacturer.
 - b. Constituent parts that are alike shall be products of a single manufacturer.
 - c. Components shall be compatible with each other and with the total assembly for intended service.
 3. All systems and equipment shall be free from defects that would adversely affect the performance, maintainability or appearance of individual components or overall assembly.
 4. Each product shall be designed for the service conditions specified for that product. If no conditions are specified, the product shall be suitable for the actual service conditions.
- I. Manufacturer's Identification: Components of equipment shall bear manufacturer's name or trademark and model number on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment. Refer to Part 2 for requirements for pre-engineered direct-buried systems.
- J. Radiographic Testing of Welds: Weld examination methods and procedures and the interpretation of examining films shall conform to ASME B31.1. The testing firm shall utilize the proper film exposure, techniques, and penetrameter to produce density and geometric sharpness required for first quality film, and all radiographs shall be reviewed and interpreted and reading reports signed by not less than an American Society for Non-Destructive Testing (ASNT) Certified Level III Radiographer.

1.05 SUBMITTALS

- A. Submit in accordance with Section 01 33 23 – Shop Drawings, Product Data and Samples.

- B. Submit information and materials under this section separate from information and materials submitted under other sections and mark "SUBMITTED UNDER Section 33 63 00 – Steam Energy Distribution, Group I, II or III."
- C. Submit all items listed under each group simultaneously (except for items that can only be submitted during construction and upon completion of construction).
 - 1. Group I, Pre-Engineered Direct-Buried Systems:
 - a. Certification that system manufacturer regularly and currently manufactures direct-buried systems, and that the designs of the system and equipment to be provided for this project conform to specification requirements. This certification shall be an original signed by a principal officer of the manufacturer.
 - b. Complete descriptions and Drawings of design of system and materials of construction including component parts, assembly, carrier pipes, casing, anchors, pipe guides, pipe supports, expansion loops, manhole and building wall penetrations, end seals, leak plates, field installation instructions.
 - c. Manufacturer's data sheets on casing coatings. Provide test report that concludes that coating can withstand a minimum 96 hour test at 186 degrees C (366 degrees F) without disbonding from the steel jacket.
 - d. A detailed design layout of the system showing the size, type, and location of each component, the design of anchors and manhole and building wall penetrations, the design of the transition points to aboveground or other type systems. Also, if applicable, the type and details of the cathodic protection system including dielectric gaskets.
 - e. Manufacturer's quality assurance plan for fabrication, delivery, storage, installation and testing of system.
 - f. Certificate of Qualification from system manufacturer that the manufacturer's field representative regularly performs the specified duties of monitoring the installation of the system and is technically qualified and experienced in the installation of the system and is authorized by the supplier to make and sign the daily reports specified herein.
 - g. Manufacturer's data sheets and thickness of carrier pipe insulation.
 - h. Calculations approved and stamped by Professional Engineer demonstrating that allowable stress of piping will not be exceeded due to thermal expansion and that anchor forces and moments are not excessive. Calculations shall be performed by a finite-element, three-dimensional analysis computer program. Final report shall show node stresses, forces, moments and displacements.
 - i. All Drawings and calculations shall have Professional Engineer's stamp.
 - j. A proposed schedule of activities indicating when various items of work and tests are to be carried out and when quality control inspectors of the supplier will be present at the job site.
 - k. The daily written report from the manufacturer's representative at the job site during all stages of material delivery and construction.
 - l. Proposed changes in design due to unforeseen conflicts or interferences along the route of the system.
 - m. Upon completion of the work:
 - 1) Certificate of Compliance signed by principal officers of the manufacturer and the contractor certifying that the system has been installed in accordance with contract requirements.
 - 2) Operation and maintenance manual.

- 3) As-built layout of system including all final elevations (hard copies and AutoCAD on CD).
2. Group II, Piping in Manholes, Concrete Tunnels, Concrete Shallow Trenches, Open Areas:
 - a. Pipe, valves, strainers and fittings.
 - b. Steam traps including orifice sizes, capacities.
 - c. Pipe hangers, brackets, supports, racks, anchors, guides.
 - d. Pipe hanger calculations.
 - e. Pipe insulation, jackets, adhesives and cements. Submit samples and technical information.
 - f. Layout Drawings showing all piping, maintenance and operation access and sumps to scale.
3. Group III, Concrete Tunnels and Manholes:
 - a. Tunnel and manhole plans, profiles, sections and details.
 - b. Manhole frames, covers and steps.
 - c. Access doors and ladders.
 - d. Gravity ventilators and louvers.
 - e. Shop Drawings for prefabricated tunnel sections and manholes.
 - f. Sumps and sump pumps.
4. Group V, Expansion Joints and Ball Joints:
 - a. Joint locations, sizes, types, movements.
 - b. Anchor locations, design, forces and moments.
 - c. Certification that expansion joints conform to service requirements and to design standards of Expansion Joint Manufacturers Association.
 - d. Certification that representative of expansion joint manufacturer has reviewed the applications in detail and has taken no exception.
 - e. Certified test data on number of cycles to failure on similar units at project service conditions - bellows type and expansion compensators.
- D. Independent Weld Testing Firm for Carrier Piping in Pre-Engineered Direct- Buried and Concrete Shallow Trench Systems:
 1. Certificate of Qualification of testing firm.
 2. Certificate of Acceptability of actual welds.
- E. Proposed test procedures and samples of test data sheets for each required test, 30 days prior to the test date. Provide calibration data on all test instruments. Tests shall not begin until procedures have been approved.
- F. Test reports resulting from testing of installed systems, in booklet form showing all field tests performed to prove compliance with specified performance criteria.

1.06 STORAGE AND HANDLING

- A. Equipment and material placed on the job shall remain in the custody of the Contractor until final acceptance whether or not the Government has reimbursed the Contractor for the equipment and material.

- B. The Contractor is solely responsible for the protection of the equipment and material against damage from any source. Protect piping systems against entry of water and mud and all foreign substances by installing watertight protection on open ends at all times. Protect direct-buried system coatings from ultraviolet light (sunlight). Existing equipment worked on by the Contractor or in the Contractor's working area shall be under the custody and responsibility of the Contractor.
- C. All insulated piping systems exposed to water must be replaced with new systems.
- D. Place all damaged items in first class new operating condition or replace damaged items as determined and directed by the Resident Engineer (RE)/Contracting Officers Technical Representative (COTR), at no additional cost to the Government.

1.07 JOB CONDITIONS

- A. Phasing of demolition and construction shall be in accordance with the provisions of Section 01 00 00 – General Requirements, and as shown on steam distribution Drawings.
- B. Steam and Condensate Service Interruption: One steam and condensate interruption shall be permitted, at which the Contractor shall make the final connections at each end of the new tunnel. The conditions shall be made when the demands are not critical to the operation of the medical center. This non-critical period is limited to one 18-hour period between 8 p.m. Friday and 2 p.m. Saturday. The period shall be all inclusive and include time for pipe cooldown, pipe demo, pipe installation, and slow pipe warm-up to prevent condensate slugs from forming in the pipe. Provide at least 4 weeks' advance notice to the COTR.

1.08 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. Federal Specifications (Fed. Spec.):
 - 1. A-A-60005 NOT 1: Frames, Covers, Grating, Steps, Sump and Catch Basin, Manhole
 - 2. L-P-535E: Plastic Sheet (Sheeting): Plastic Strip: Poly (Vinyl Chloride) and Poly (Vinyl Chloride-Vinyl Acetate)
 - 3. L-S-125B: Screening, Insect, Nonmetallic
- C. Military Specifications (Mil. Spec.):
 - 1. MIL-S-901D: Shock Tests. H.I. (High Impact) Shipboard Machinery, Equipment and Systems
- D. ASTM International (ASTM):
 - 1. A36/A36M-05: Structural Steel
 - 2. A47/A47M-99(2004): Ferritic Malleable Iron Castings
 - 3. A53/A53M-06a: Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
 - 4. A105/A105M-05: Carbon Steel Forgings for Piping Applications
 - 5. A106/A106M-06a: Seamless Carbon Steel Pipe for High-Temperature Service
 - 6. A126-04: Gray Iron Castings for Valves, Flanges and Pipe Fittings
 - 7. A134-96(2005): Pipe, Steel, Electric-Fusion(Arc)-Welded (Sizes NPS 16 and over)
 - 8. A135/A135M-06: Electric-Resistance Welded Steel Pipe
 - 9. A139/A139M-04: Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and over)

10. A167-99(2004): Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
 11. A193/A193M-07: Alloy-Steel and Stainless Steel Bolting Materials for High Temperature Service
 12. A194/A194M-07a: Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
 13. A197/A197M-00(2006): Cupola Malleable Iron
 14. A216/A216M-07: Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
 15. A234/A234M-07: Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
 16. A240/A240M-07e1: Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
 17. A395/A395M-99(2004) : Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures
 18. A536-84(2004) : Ductile Iron Castings
 19. B61-02: Steam or Valve Bronze Castings.
 20. B209-06: Aluminum and Aluminum-Alloy Sheet and Plate
 21. C411-05: Hot-Surface Performance of High-Temperature Thermal Insulation
 22. C449/C449M-00: Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
 23. C533-07: Calcium Silicate Block and Pipe Thermal Insulation
 24. C547-06: Mineral Fiber Pipe Insulation
 25. C552-03: Cellular Glass Thermal Insulation
 26. C591-07: Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
 27. C655-04e1 Reinforced Concrete D-Load Culvert, Storm Drain and Sewer Pipe
 28. C920-05: Elastomeric Joint Sealants
 29. C1126-04: Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation
 30. C1136-06: Flexible, Low Permeance Vapor Retarders for Thermal Insulation
 31. D1784-06a: Rigid Poly (Vinyl Chloride)(PVC) Compounds and Chlorinated Poly (Vinyl Chloride)(CPVC) Compounds
 32. D2310-06: Machine-Made "Fiberglass" (Glass-Fiber Reinforced Thermosetting-Resin) Pipe
 33. D2487-06: Soils for Engineering Purposes (Unified Classification System)
 34. D2996-01(2007)e1: Filament-Wound Fiberglass (Glass-Fiber-Reinforced-Thermosetting-Resin) Pipe
- E. American Society of Mechanical Engineers (ASME):
1. B16.3-2006: Malleable Iron Threaded Fittings
 2. B16.5-2003: Pipe Flanges and Flanged Fittings NPS 1/2 – 24
 3. B16.9-2003: Factory-Made Wrought Buttwelding Fittings
 4. B16.11-2005: Forged Fittings, Socket-Welding and Threaded
 5. B31.1-2004: Code for Pressure Piping, Power Piping, with Amendments
 6. B31.9-2004: Code for Pressure Piping, Building Services Piping, with Amendments
 7. B40.100-2005: Pressure Gauges and Gauge Attachments
 8. Boiler and Pressure Vessel Code, Section VIII: 2007 Edition, with Amendments
- F. American Welding Society (AWS):
1. AWS B2.1-00: Welding Procedure and Performance Qualification
- G. Manufacturers Standardization Society of the Valve and Fitting Industry (MSS):
1. SP45-03: By-Pass and Drain Connection Standard
 2. SP58-02: Pipe Hangers and Supports – Materials, Design and Manufacture
 3. SP69-03: Pipe Hangers and Supports – Selection and Application

- 4. SP80-03: Bronze Gate, Globe, Angle and Check Valves
- H. National Fire Protection Association (NFPA):
 - 1. 255-06: Test of Surface Burning Characteristics of Building Materials
- I. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
 - 1. ASHRAE Handbook: 2004 HVAC Systems and Equipment
- J. American Concrete Institute (ACI):
 - 1. 318-05: Building Code Requirements for Reinforced Concrete
- K. NACE International (Corrosion Engineers) (NACE):
 - 1. RP0169-02: Standard Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems
- L. Expansion Joint Manufacturers Association (EJMA):
 - 1. 8th Edition-2003: Standards of the Expansion Joint Manufacturers Association
- M. American Association of State Highway and Transportation Officials (AASHTO):
 - 1. M300-03: Inorganic Zinc Rich Primer
- N. Society for Protective Coatings (SSPC):
 - 1. SP-10/NACE No. 2-2004: Near White Blast Cleaning
- O. Unified Facilities Guide Specifications (UFGS):
 - 1. UFGS 33 63 13: Exterior Underground Steam Distribution System (April 2006 or later)

PART 2 PRODUCTS

2.01 PRE-ENGINEERED, FACTORY-FABRICATED, DIRECT-BURIED, DRAINABLE-DRYABLE-TESTABLE (DDT) SYSTEMS

- A. Complete steam and condensate piping system with carrier pipes, carrier pipe insulation with jackets and banding, air space, 6.35 mm (0.25 inch) thick steel casing, fusion-bonded epoxy casing coatings, cathodic protection, accessories. Do not locate condensate pipes in casings (conduits) that contain steam pipes.
- B. Design Pressure and Temperature: All components of system shall be suitable for carrier pipe pressures and temperatures as follows:
 - 1. Steam System: 1000 kPa (150 psi); 185 degrees C (366 degrees F).
 - 2. Condensate System: 345 kPa (50 psi); 154 degrees C (310 degrees F).
- C. Description of System Design: Refer to Part 1, "DEFINITIONS."
- D. Steam Carrier Pipes: Refer to Paragraph, "STEAM PIPING."
 - 1. No piping joints allowed in factory-fabricated straight sections of pre-engineered direct-buried systems.

2. Factory-fabricated direct-buried piping sections that are a portion of an expansion loop or bend shall have all welded joints 100 percent radiograph inspected.

E. Condensate Carrier Pipes: Refer to Paragraph, "STEAM CONDENSATE PIPING."

1. No piping joints allowed in factory-fabricated straight sections of pre-engineered direct-buried systems.
2. Factory-fabricated direct-buried piping sections that are a portion of an expansion loop or bend shall have all welded joints 100% radiograph inspected.

F. Carrier Pipe Insulation:

1. Conform to minimum thickness and type of insulation listed in Tables 1 and 2 below as required for service temperature in carrier pipe as listed below.
2. Steam pressure is 100 psi. Pumped condensate temperature is 93 degrees C (200 degrees F).
3. Allowable Carrier Pipe Insulation Type and Minimum Insulation Thickness:

TABLE 1 Minimum Pipe Insulation Thickness mm (inches) For Steam 110 to 2800 kPa (16 to 408 psi) gauge				
Nominal Diameter (inches)	Pipe mm	MPT-PC MPT-PF	Delta	Thermo-12 Super Caltemp
25 (1)		50 (2)	65 (2 1/2)	100 (4)
40 (1 1/2)		50 (2)	65 (2 1/2)	100 (4)
50 (2)		65 (2 1/2)	85 (3 1/2)	110 (4 1/2)
65 (2 1/2)		65 (2 1/2)	85 (3 1/2)	110 (4 1/2)
80 (3)		75 (3)	100 (4)	125 (5)
100 (4)		75 (3)	100 (4)	125 (5)
125 (5)		75 (3)	100 (4)	125 (5)
150 (6)		85 (3 1/2)	110 (4 1/2)	135 (5 1/2)
200 (8)		85 (3 1/2)	110 (4 1/2)	135 (5 1/2)
250 (10)		100 (4)	125 (5)	150 (6)
300 (12)		100 (4)	125 (5)	150 (6)
350 (14)		100 (4)	125 (5)	150 (6)
400 (16)		100 (4)	125 (5)	150 (6)
450 (18)		100 (4)	125 (5)	150 (6)

Notes: Insulation listed has passed the 96-hour boiling water test.

Pipes smaller than 25 mm (1 inch) shall have same insulation thickness as 25 mm (1 inch) pipe.

TABLE 2 Minimum Pipe Insulation Thickness mm (inches) For Steam Less than 110 kPa (16 psi) gauge, Condensate Return				
Nominal Diameter (inches)	Pipe mm	MPT-PF MPT-PC	Delta	Thermo-12 Super Caltemp
25 (1)		40 (1 1/2)	50 (2)	75 (3)
40 (1 1/2)		40 (1 1/2)	50 (2)	75 (3)
50 (2)		40 (1 1/2)	50 (2)	75 (3)
65 (2 1/2)		40 (1 1/2)	50 (2)	75 (3)
80 (3)		50 (2)	65 (2 1/2)	85 (3 1/2)
100 (4)		50 (2)	65 (2 1/2)	85 (3 1/2)
125 (5)		50 (2)	65 (2 1/2)	85 (3 1/2)
150 (6)		65 (2 1/2)	80 (3)	110 (4.5)
200 (8)		65 (2 1/2)	80 (3)	110 (4.5)
250 (10)		80 (3)	100 (4)	125 (5)
300 (12)		80 (3)	100 (4)	125 (5)
350 (14)		80 (3)	100 (4)	125 (5)
400 (16)		80 (3)	100 (4)	125 (5)
450 (18)		80 (3)	100 (4)	125 (5)

Notes: Insulation listed has passed the 96-hour boiling water test which indicates that satisfactory performance in underground service can be expected.

Pipes smaller than 25 mm (1 inch) shall have the same insulation thickness as required for 25 mm (1 inch) pipe.

"Delta" is available from Rockwool, Leeds, AL.

"MPT" is available from Mineral Products of Texas, Houston, Texas.

"Thermo-12" and "Super Caltemp" is available from Industrial Insulation Group, Brunswick, GA.

5. Insulation Banding and Jacket: Stainless steel bands and clips, at least 13 mm (0.5 inches) wide, ASTM A167 (304 stainless steel), maximum spacing 460 mm (18 inches). A minimum of two bands is required for each 1300 mm (4 foot) section of insulation. Vinyl-coated fiberglass scrim jacket, Fed. Spec. L-S-125, Type II, Class 2, with 18 by 16 mesh (number of filaments per inch) and made of 0.335 mm (0.013 inches) diameter vinyl-coated fibrous glass yarn. Install bands over the jacket to secure the insulation to the carrier pipe.
- G. Casing: Smooth-wall steel, electric resistance welded, conforming to ASTM A134, ASTM A135 or ASTM A139. Plastic casings are not permitted. Use eccentric connectors as necessary between casing sections to provide continuous gravity drainage in bottom of casing between manholes and between manholes and buildings.

Casing Diameter mm (in.)	Minimum Thickness mm (in.)
150 - 1170 (6 - 46)	6.35 (0.250)

- H. Casing End Seal Plates with Vents and Drains: ASTM A36 steel, minimum thickness 9.5 mm (0.375 inches) for casings up thru 300 mm (12 inches) diameter and 13 mm (0.5 inches) for casings over 300 mm (12 inches) diameter. Provide 25 mm (one inch) drain at the

bottom and vent at the top. Construct with threaded steel half couplings. Install threaded brass plugs in drains. Install vent riser pipes, ASTM A53, Schedule 40, galvanized, extending through top of manhole and terminate 300 mm (12 inches) above grade with 180-degree bend.

- I. Gland Seals: Not permitted because of the possibility of water entering the system thru the gland seal from a flooded manhole.
- J. Air Space: Provide continuous 25 mm (one inch) minimum air space between carrier pipe insulation and casing.
- K. Casing Coating: Dual layers of fusion-bonded epoxy, inner green-colored layer minimum thickness 0.5 mm (0.020 inches), outer black-colored layer minimum thickness 0.25 mm (0.010 inches). Rated by coating manufacturer for continuous service for at least 25 years at minimum temperature of 110 °C (230 °F) and having a coefficient of expansion similar to that of steel. Coating shall be applied in accordance to recommendations of coating manufacturer including surface preparation. Factory-inspect for holidays and make repairs as necessary.
- L. Coating of End Plates and Casing (Conduit) Sections Extending in Manholes: Zinc-rich coating that conforms to AASHTO M300, Type IA except that volatile organic compounds shall not exceed 0.34 kg per liter (2.8 pounds per gallon). The zinc rich coating shall be applied in accordance with the recommendations of the coating manufacturer including surface preparation. No additional top coat shall be applied.
- M. Carrier Pipe Guides and Supports: Maximum spacing 3000 mm (10 feet) on centers, no more than 1500 mm (5 feet) from pipe ends, minimum of three guides per elbow section. Designed to permit thermal expansion without damage, provide proper pipe guiding and support, and to allow horizontal movement in two directions as necessary at expansion loops and bends. Design of guides and supports must permit continuous drainage of water in bottom of casing. Pipe insulation shall extend thru the pipe guides and supports and be protected by steel sleeves. Design of guides and supports shall be such that no metal-to-metal contact exists between the casing and the carrier pipe. Insulation or non-metallic material used to ensure no metal to metal contact shall be designed to not be compressed by the weight of the carrier pipe when full of water.
- N. Anchor Plates: ASTM A36 steel, welded to carrier pipe and casing, 13 mm (0.5 inches) minimum thickness, passages for air flow and water drainage thru the annular air space in the system. Coated with same coating material as the casing. Locate 900 to 1500 mm (3 to 5 feet) from piping entrance to manhole or building wall. Walls of manholes and buildings cannot be utilized as anchor points.
- O. Field Connection of Casing Sections: Steel section conforming to casing specification, welded to casing sections, coated on all surfaces with system manufacturer's coating field repair compound, and covered with a 1.3 mm (0.05 inch) minimum thickness polyethylene shrink sleeve designed for a service temperature exceeding 80 °C (176 °F).
- P. Manhole and Tunnel Wall Penetrations: Provide steel leak plates welded to wall sleeves or to casings. Where wall sleeve is utilized, allow sufficient annular space between the sleeve and the casing and install a watertight EPDM Link-Seal (Thunderline Corp) or equal, rated for 121 degrees C (250 degrees F) minimum. Manhole and building walls cannot be used as anchor points.

- Q. Manufacturer's Identification: Provide embossed brass or stainless steel tag hung by a brass or stainless steel chain at each end of each conduit or insulated piping in the manholes and buildings. The tag shall identify system manufacturer's name, date of installation, government contract, and manufacturer's project number.
- R. Branch Piping Connections: All branch piping connections must be located in manholes.
- S. Manufacturers: Perma-Pipe, Rovanco, Thermacor or equal.

2.02 MANHOLES

- A. Concrete Construction: Reinforced concrete conforming to Section 03 30 00 – Cast-In-Place Concrete, not less than 200 mm (8 inches) thick. Pour monolithically where possible. Place waterproof membrane as specified in Section 07 12 00 – Built-Up Bituminous Waterproofing, between mud slab and bottom concrete slab, and continue up sides to top of sidewalls. Joints between manhole walls and conduit casings or concrete trench sections shall be watertight. Steel manholes or prefabricated concrete manholes are not permitted.
- B. Manhole Access Frames, Covers and Steps: Provide each manhole with cast iron manhole frames and solid covers, not less than 700 mm (28 inch) clear openings, Fed. Spec. A-A-60005. Unless otherwise shown on the Drawings, frames and covers shall be as follows:
 - 1. For non-traffic applications:
 - a. Frame - Type IV, Size 28
 - b. Cover - Type E, Size 28, cast identification "STEAM."
 - 2. For traffic applications:
 - a. Frame - Type I, Style A, Size 27A
 - b. Cover - Type A, Size 27A, cast identification "STEAM."
 - 3. Manhole steps: Standard, cast-iron, Fig. 19, Fed. Spec. A-A-60005.
- C. Ventilation: Provide manhole ventilation as indicated on Drawings. Construct ventilation ducts of galvanized steel sheet metal and in accordance with ASHRAE Handbook recommendations for low pressure ducts. Gravity ventilators shall be factory fabricated of aluminum or galvanized steel and arranged as indicated on Drawings. Ventilating pipes shall be standard weight black steel and installed as shown on Drawings.
- D. Drainage: Provide as shown on Drawings.
- E. Electric Sump Pumps with Automatic Controls and High Water Alarm:
 - 1. Type: High temperature submersible duplex pumps and automatic controls.
 - 2. Service: Continuous operation at required flows and pressures while completely submerged at 93 °C (200 °F). All pumps and pump controls shall have demonstrated 200,000 cycles of operation at 93 °C (200 °F) and 100% relative humidity while totally submerged in water.
 - 3. Performance: Capacity and pressure as required by the Drawings. Pumps shall be capable of passing 10 mm (0.375 inch) spheres. Pumps and motors shall be capable of operating continuously without damage when not submerged.
 - 4. Construction: Epoxy-coated cast iron casing, cast iron impeller, stainless steel shaft, carbon/ceramic shaft seal, stainless steel hardware, permanently lubricated bearings, screened inlets. Schedule 80 discharge pipe protected from corrosion.

5. Motors: Non-overloading at all points on the pump performance curve. Overload protection.
6. Controls: Automatic alternating lead-lag. Damp-proof electrical service.
7. High Water Alarm: Switch set at level below lowest steam or condensate pipe in the manhole. Switch shall activate weatherproof red alarm light mounted above manhole entrance. Provide contacts for future connection to engineering control center.
8. Pump Manufacturers: Barnes, Zoeller or equal.

2.04 TUNNELS (WALK-THROUGH)

- A. Cast-In-Place Concrete: Reinforced concrete conforming to Section 03 30 00 – Cast-In-Place Concrete. Place waterproof membrane between mud slab and bottom concrete slab and continue up sides and over top of tunnel roof slab. Apply waterproofing as specified in Section 07 12 00 – Built-Up Bituminous Waterproofing.
- B. Precast Concrete Pipe Tunnel: Construct straight runs of tunnel of precast reinforced concrete pipe sections conforming to ASTM C655 and in full compliance with ACI 318. Manufacturer shall have a minimum of five years experience in the design and fabrication of similar precast concrete units. Manufacturer shall have an established quality assurance program in operation and show current certification in Precast/Prestressed Concrete Institute (PCI) plant certification program. Concrete mix and reinforcing shall be manufacturer's standard product for this service. Provide cast-in-place concrete tunnel sections at each bend and at each change in grade of the tunnel. Mortar shall be as recommended by the precast concrete tunnel manufacturer.
- C. Ventilation: Ducts shall be galvanized sheet steel constructed in accordance with ASHRAE Handbook recommendations. Gravity ventilators shall be factory fabricated of aluminum or galvanized steel.
- D. Drainage: Provide drainage system at all low points of tunnel systems as shown on the Drawings.

2.05 STEAM CARRIER PIPING

- A. Pipe: Steel; seamless, ASTM A53, Grade B or ASTM A106, Grade B; electric resistance welded ASTM A53, Grade B; Schedule 40. Standard weight permitted for pipe sizes 300 mm (12 inches) and above. Grade F, furnace butt-welded pipe, is not permitted.
- B. Joints:
 1. In trenches and direct-buried systems: Butt-weld except socket-weld for pipe sizes two inches and below. Manufacturer's standard sliding gasketed joints permitted between sections of WSL pre-engineered direct-buried systems. No joints allowed in factory-fabricated straight sections of pre-engineered direct-buried systems. Factory-fabricated direct-buried piping sections that are a portion of an expansion loop or bend shall have all welded joints 100% radiograph inspected. All radiographs shall be reviewed and interpreted by an American Society for Non-Destructive Testing (ASNT) Certified Level III radiographer, employed by the testing firm, who shall sign the reading report. Dye penetrant testing may be utilized for pipe sizes 50 mm (2 inches) and below.

2. In tunnels, manholes and open areas: Butt-weld pipe sizes 65 mm (2-1/2 inches) and above; thread or socket-weld pipe sized 50 mm (two inches) and below.

C. Fittings:

1. Butt-Welded Joints: Steel, ASTM A234, Grade B, ASME B16.9, same schedule as adjoining pipe. All elbows shall be long radius unless otherwise indicated. Tees shall be full size or reducing as required, having interior surfaces smoothly contoured.
2. Threaded Joints: Malleable iron, ASTM A47 or A197, ASME B16.3, 2050 kPa (300 pound) class.
3. Socket-Welded Joints: Forged steel, ASME B16.11, 13,800 kPa (2000 psi) class.

D. Flanges and Bolts: Weld neck, ASME B16.5, forged steel, ASTM A105. Pressure class 1025 kPa (150 psi). Bolts shall be high strength ASTM A193, Class 2, Grade B8. Nuts shall be ASTM A194.

E. Unions: On pipe 50 mm (two inches) and smaller, threaded, malleable iron or steel, 2050 kPa (300 psi) class.

2.06 STEAM CONDENSATE CARRIER PIPING

A. Pipe: Seamless, ASTM A53, Grade B or ASTM A106, Grade B; electric resistance welded ASTM A53, Grade B; Schedule 80. Grade F, furnace butt-welded, pipe is not permitted.

B. Joints:

1. In Trenches and direct-buried systems: Butt-weld except socket-weld is required for pipe sizes 50 mm (two inches) and below. Manufacturer's standard sliding, gasketed joints permitted between factory-fabricated sections of direct buried WSL system. No joints allowed in factory-fabricated straight sections of pre-engineered direct-buried systems. Factory-fabricated direct-buried piping systems that are a portion of expansion loops or bends shall have all welded joints 100% radiograph inspected. All radiographs shall be reviewed and interpreted by an ASNT Certified Level III radiographer, employed by the testing firm, who shall sign the reading report. Dye penetrant testing may be utilized for pipe sizes 50 mm (2 inches) and below.
2. In Tunnels, Manholes and Open Areas: Butt-weld pipe sizes 65 mm (2-1/2 inches) and above; thread or socket-weld for pipe sizes 50 mm (two inches) and below.

C. Fittings:

1. Welded Joints: Steel, ASTM A234, Grade B, ASME B16.9, same schedule as adjoining pipe.
2. Threaded Joints: Malleable iron, ASTM A47 or A197, ASME B16.3, 2050 kPa (300 psi) class.
3. Socket-Welded Joints: Forged steel, ASME B16.11, 13,800 kPa (2000 psi) class.

- D. Unions (Except in Trenches): On piping 50 mm (two inches) and under, 2050 kPa (300 psi) malleable iron or steel.
- E. Flanges: Weld neck ASME B16.5, forged steel, ASTM A105, 1025 kPa (150 psi).

2.07 EXPANSION JOINTS

- A. Factory built devices, inserted in the pipelines, and designed to absorb axial cyclical pipe movement that results from thermal expansion and contraction. Provide factory-built or field-fabricated guides located along the pipelines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.
- B. Minimum Service Requirements:
 - 1. Pressure Containment:
 - a. Steam Service 35-200 kPa (5-30 psi): Rated 345 kPa (50 psi) at 148 degrees C (298 degrees F).
 - b. Steam Service 214-850 kPa (31-125 psi): Rated 1025 kPa (150 psi) at 186 degrees C (366 degrees F).
 - c. Steam Service 869-1025 kPa (126-150 psi): Rated 1375 kPa (200 psi) at 194 degrees C (382 degrees F).
 - d. Condensate Service: Rated 690 kPa (100 psi) at 154 degrees C (310 degrees F).
 - 2. Number of Full Reverse Cycles without failure: Minimum 1000.
 - 3. Movement: As shown on Drawings plus recommended safety factor of manufacturer.
- C. Manufacturing Quality Assurance: Conform to EJMA Standards.
- D. Bellows - Externally Pressurized Type:
 - 1. Multiple corrugations of ASTM A240, Type 304 stainless steel.
 - 2. Internal and external guides integral with joint.
 - 3. Design for external pressurization of bellows to eliminate squirm.
 - 4. Welded ends.
 - 5. Conform to the standards of EJMA and ASME B31.1.
 - 6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.
 - 7. Integral external cover and internal sleeve.
- E. Expansion Joint Identification: Provide stamped brass or stainless steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the Contract Drawings.
- F. Guides: Provide factory-built guides along the pipeline to permit axial movement only and to restrain lateral and angular movement. Guides must be designed to withstand a minimum of 15 percent of the axial force that will be imposed on the expansion joints and anchors. Field-built guides may be used if detailed on the contract Drawings. Guide locations must conform to recommendations of expansion joint manufacturer and EJMA.

2.08 VALVES

- A. Valves for particular services are generally specified as Type Numbers. The Type Numbers are defined below. All valves of the same type shall be the products of a single manufacturer

and shall comply with MSS SP45, MSS SP80 and ASME B31.1. Design valves for the service fluids and conditions. Pressure - temperature ratings listed are minimum requirements. Packing and gaskets must be asbestos-free.

B. Valve Type Designations:

1. Gate Valves:

- a. Type 101: Cast steel body ASTM A216 WCB, rated 1025 kPa (150 psi) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chromium stainless steel flexible wedge and hard faced (stellite) or nickel-copper alloy seats, 1025 kPa (150 psi) ASME flanged ends, OS&Y, rising stem, bolted bonnet.
 - 1) Provide factory installed globe valved bypass on all steam valves larger than 80 mm (3 inches). Conform to MSS SP45.
 - 2) Drill and tap bosses for connection of drains where shown. Conform to MSS SP45.
- b. Type 102: Not used.
- c. Type 103: Cast iron body ASTM A126 Class B, rated for 850 kPa (125 psi) saturated steam, 1375 kPa (200 psi) WOG, bronze or bronze faced wedge and seats, 850 kPa (125 psi) ASME flanged ends, OS&Y, rising stem, bolted bonnet, renewable seat rings.
- d. Type 104: Bronze body ASTM B61, rated for 1375 kPa (200 psi) saturated steam, 2750 kPa (400 psi) WOG, bronze wedges and Monel or stainless steel seats, threaded ends, rising stem, union bonnet.
- e. Type 105: Not used.
- f. Type 106: Forged steel body ASTM A105, rated for 2050 kPa (300 psi) at 216 °C (420 °F) minimum (Class 4130 kPa (600 psi) or Class 5500 kPa (800 psi)), hardened stainless steel or stellite wedge and seats, threaded ends, OS&Y, rising stem, bolted bonnet.

2. Check valves:

- a. Type 401: Cast steel body ASTM A216, swing-type, rated for 1025 kPa (150 psi) at 260 °C (500 °F), stainless steel or stainless steel - faced disc and seat, 1025 kPa (150 psi) ASME flanged ends, bolted cover, renewable disc.
- b. Type 402: Not used.
- c. Type 403: Cast iron body ASTM A126 Class B, swing-type, rated for 850 kPa (125 psi) saturated steam, 1375 kPa (200 psi) WOG, bronze or bronze-faced disc and seat, 850 kPa (125 psi) ASME flanged ends, bolted cover, renewable disc and seat.
- d. Type 404: Bronze body ASTM B61, swing-type, rated for 1375 kPa (200 psi) saturated steam, 2750 kPa (400 psi) WOG, bronze disc, threaded ends, regrounding disc.

C. Valve Applications (Steam Lines):

- 1. Gate valves, 50 mm (two inches) and under: Type 106.
- 2. Gate valves, 65 mm (2-1/2 inches) and above: Type 101.
- 3. Globe valves, 50 mm (two inches) and under: Type 204.
- 4. Globe valves, 65 mm (2-1/2 inches) and above: Type 201.
- 5. Check valves, 50 mm (two inches) and under: Type 404.
- 6. Check valves, 65 mm (2-1/2 inches) and above: Type 401.

7. Ball valves, 50 mm (two inches) and under: Type 502
8. Ball valves, 65 mm (2-1/2 inches) and above: Type 504.
9. Butterfly valves, all sizes: Type 602.

D. Valve Applications (Condensate Lines):

1. Gate valves, 50 mm (two inches) and under: Type 104.
2. Gate valves, 65 mm (2 1/2 inches) and above: Type 103.
3. Globe valves, 50 mm (two inches) and under: Type 204.
4. Globe valves, 65 mm (2 1/2 inches) and above: Type 203.
5. Check valves, 50 mm (two inches) and under: Type 404.
6. Check valves, 65 mm (2 1/2 inches) and above: Type 403.
7. Ball valves, 50 mm (two inches) and under: Type 502.
8. Ball valves, 65 mm (2-1/2 inches) and above: Type 504.
9. Butterfly valves, all sizes: Type 601.

2.09 STEAM TRAPS

- A. Apply at steam line drip points.
- B. Inverted bucket type with thermostatic vent in bucket, except closed-float-thermostatic on discharge side of pressure reducing stations. Each type furnished by a single manufacturer. Select the traps for pressures and capacities as shown or required. Fixed orifice or Venturi type traps are not permitted.
- C. Cast iron or stainless steel bodies. Construction shall permit ease of removal and servicing working parts without disturbing connecting piping.
- D. Stainless steel floats. Hardened chrome steel valves. Stainless steel mechanisms. Bi-metallic air vent on inverted bucket traps.
- E. Provision for Future Trap Performance Monitoring System: All traps shall include ports for future installation of monitoring devices such as Armstrong "Steam Eye" or equal. To facilitate future removal of plugs, remove plugs, install Teflon tape on the threads, and reinstall the plugs.
- F. Identification: Label each trap at the factory with an identification number keyed to the contract Drawings. Label shall be a metal tag permanently attached to the trap.

2.10 PIPE HANGERS AND SUPPORTS

- A. Applies to all piping not in factory-fabricated direct-buried system. All systems shall be completely supported. Arrange supports so that all loads due to weight, thermal expansion, seismic shock (if applicable), and pressure are transferred from the support system to the structure. The design and location of supports shall at all times prevent excessive forces, moments, and stresses from being imposed on the equipment, structure, supported system, and supports. Heated systems generally require resilient or roller/slide supports.
- B. Standards: Comply with recommendations and requirements of MSS SP-58, MSS SP-69 and ASME B31.1.
- C. Design:
 1. Components: Factory-built products of a manufacturer whose principle business is pipe supports. All components must have published load ratings. For concrete

trenches, non-factory built products that comply with details shown on the contract Drawings may also be utilized.

2. Selection of Components: Types, sizes, locations, and spacing must conform to MSS SP-69. Horizontal steam and condensate piping shall have roller or slider supports. Supports at risers shall be spring type that accommodates the thermal expansion. Contract Drawings may show locations and types of supports including rollers and springs, and may also show special supports including anchors, guides and braces. Rigid supports such as clevises are generally not shown. Technical personnel employed by the support manufacturer shall do final selection of components, locations and sizes. If equipment and piping arrangement differs from that shown on the Drawings, support locations and types shall be revised at no cost to the government. Locate supports to permit removal of valves and strainers from pipelines without disturbing supports.
 3. Spring Hangers: Provide on all systems subject to vertical movement.
 4. Roller Hangers and Sliding Supports: Provide on all systems subject to horizontal movement due to thermal expansion except when long hanger rods permit sufficient horizontal movement. If vertical angle of hanger rod exceeds four degrees, rollers or sliders are required.
 5. Calculations: Calculate loads for all supports. On systems utilizing variable spring supports, determine the loads at each support by calculating the forces and moments throughout the system.
 6. Deflection of Supported Systems: Vertical deflection due to system weight shall not exceed 2.5 mm (0.1 inch) between supports when system is filled with fluid normally carried.
 7. All support assemblies from above shall include threaded connections that permit vertical position adjustment.
 8. Layout Drawings and Identification of Hanger Parts: Prepare Drawings showing each hanger location and identifying each hanger by number. Prepare individual Drawing for each hanger assembly showing all components, sizes, calculated loadings. Provide identification tags, on each hanger part, keyed to the layout Drawings.
- D. Upper Attachments to Structure: MSS SP-58, Type 18, 20, 21, 22, 23, 29 and 30.
- E. Roller Supports: MSS SP-58, Types 41, 43, and 46. Provide vertical adjustment for Type 41 with threaded studs and nuts adjacent to the roller.
- F. Variable Spring Support Assembly: MSS SP-58, Type 51 variable spring, Type 3 pipe clamp or Type 1 clevis. Type 53 variable spring trapeze may also be used. Locate Type 51 variable spring within 300 mm (one foot) above pipe attachment. Attach rod to top of variable spring with Type 14 clevis.
- G. Spring Cushion Support Assembly:
1. Double Rod Assembly: MSS SP-58, Type 41 and 49.

2. Single Rod Assembly: MSS SP-58, Type 48 spring cushion, Type 3 pipe clamp or Type 1 clevis. Locate spring cushion within 300 mm (one foot) above pipe attachment.
- H. Clevis Supports: MSS SP-58, Type 1.
- I. Wall Brackets: MSS SP-58, Type 31, 32 and 33.
- J. Pipe Stands: MSS SP-58, Type 38.
- K. Riser Clamp: MSS SP-58, Type 42.
- L. Alignment Guides: Construct guides of welded steel as shown to restrain movement perpendicular to the long axis of the piping. If not shown, provide steel spider clamped to pipe, enclosed within steel sleeve that is bolted or welded to structural support. Spider-type guide shall be a standard manufactured product. Design to withstand lateral force equal to minimum of 15 percent of anchor loading.
- M. Trapeze Supports: May be used where pipes are close together and parallel. Construct with structural steel channels or angles. Bolt roller supports to steel to support piping subject to horizontal thermal expansion. Attach other piping with u-bolts.
- N. Pipe covering protection saddles: MSS SP-58, Type 39. Provide at all support points on insulated pipe except where Type 3 pipe clamp is provided.
- O. Sliding Supports: MSS SP-58, Type 35. Welded steel attachments to pipe and structure with Teflon or graphite sliding surfaces bonded to the attachments. Provide steel guides, except at expansion bends, to prevent lateral movement of the pipe.
- P. Pipe Racks and miscellaneous supports: Provide as shown. Construct of standard structural steel shapes, ASTM A36. Manufactured strut systems are acceptable if they have the required load-carrying ability.
- Q. All supports, including all structural steel, in trenches and manholes shall be hot-dip galvanized.

2.11 PIPE ANCHORS

- A. Provide as shown. Construct with all welded steel, ASTM A36.

2.12 INSULATION MATERIALS (IN MANHOLES, TUNNELS, CONCRETE TRENCHES, OPEN AREAS)

- A. Calcium Silicate Insulation:
 1. Preformed Piping Insulation: ASTM C533, Type I.
 2. Blocks: ASTM C533, Type I.
 3. Fitting Insulation: ASTM C533, with polyvinyl chloride, Fed. Spec. L-P-535, Type II Grade GU, and Type III, premolded fitted covering 0.5 mm (0.020 inches) thick.
- B. Fiberglass Insulation:
 1. Preformed Piping Insulation: ASTM C547, 230 °C (450 °F).

2. Fitting Insulation: ASTM C547, 230 °C (450 °F), with polyvinyl chloride, Fed. Spec. L-P-535, Type II Grade GU, and Type III, premolded fitted covering 0.5 mm (0.020 inches) thick.
- C. Insulating and Finishing Cements: Best grade recommended by printed instructions of manufacturer for the type of insulation system and service conditions. Conform to ASTM C449.
- D. Insulation Bands: Minimum 12 mm (1/2 inch) wide by 0.4 mm (0.015 inch) thick ASTM A167 stainless steel.
- E. Aluminum Jackets: Minimum 0.4 mm (0.016 inch) thick aluminum, ASTM B209, 3003 alloy, H-14 temper, with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory fabricated to match material and construction of the straight run jackets. Factory fabricated stainless steel bands shall be furnished and installed on all circumferential joints. Bands shall be 20 mm (0.75 inch) wide on 450 mm (18 inch) centers. Bands shall be applied with manufacturers recommended sealant. Entire system shall be watertight.
- F. Pipe Covering Protection Saddles: MSS SP-58, Type 39 at all hanger points except where Type 3 pipe clamps are provided.

2.13 PIPE AND VALVE FLANGE GASKETS

- A. Non-asbestos, designed for the service conditions. On steam service utilize "Flexitallic" spiral-wound, "Lamons Grafoil Grade GHR," "Lamons Spira-wound," "Garlock ST-706" or equal.

2.14 BURIED UTILITY WARNING TAPE

- A. Tape shall be 0.1 mm (0.004 inch) thick, 150 mm (6 inches) wide, yellow polyethylene with a ferrous metallic core, acid and alkali-resistant and shall have a minimum strength of 12,000 kPa (1750 psi) lengthwise and 10,300 kPa (1500 psi) crosswise with an elongation factor of 350 percent. Provide bold black letters on the tape identifying the type of system. Tape color and lettering shall be unaffected by moisture and other substances contained in the backfill material.

PART 3 EXECUTION

3.01 GENERAL

- A. Connecting to Existing Work: Connect new work to existing work in a neat and workmanlike manner. Where an existing structure must be cut or existing utilities interfere, such obstruction shall be bypassed, removed, replaced or relocated, patched and repaired. Work disturbed or damaged shall be replaced to its prior condition, as required by Section 01 00 00 – General Requirements. Piping connections shall be made only in manholes, tunnels or buildings.
- B. Coordination: Coordinate the location of all items of equipment and work of all trades. Maintain operability and maintainability of the equipment and systems. The contractor at his cost shall perform any relocation of equipment or systems to comply with the requirement of operability and maintainability.

- C. Excavation, trenching, shoring, sheathing, bracing and backfilling shall conform to Section 31 20 00 – Earth Moving.
- D. Grading: Unless otherwise shown on Drawings, steam lines shall be graded downward not less than 50 mm in 12 meters (two inches in 40 feet) in direction of the flow. Provide eccentric reducing fittings on steam mains and branches, (except on vertical piping). Install said fittings to maintain continuity of grade in bottom of pipeline. Provide risers with drip pockets and steam traps on steam lines where space restrictions prevent continuous grading. All steam traps must be located in manholes or tunnels.

3.02 DEMOLITION

- A. Perform work in accordance with requirements for phasing.
- B. Completely remove all pipe, valves, fittings, insulation and all hangers including the connection to the structure and any fastenings.
- C. Seal all openings in manhole or building walls after removal of piping.
- D. All material and equipment removed shall become the property of the Contractor and shall be removed from Government property within one week and shall not be stored in operating areas.
- E. All flame cutting shall be performed with adequate fire protection facilities available as required by safety codes and Resident Engineer.

3.03 PIPING JOINTS AND FITTINGS

- A. Welded Joints:
 - 1. Branch connections shall be made with either welding tees or welding outlet fittings. Welding outlet fittings shall be forged, integrally reinforced to provide 100 percent pipe strength, beveled for full penetration welding and funneled at inlet for full fluid flow.
 - 2. Clean pipe and fittings before welding and installation in system.
- B. Threaded Joints:
 - 1. Pipe threads shall be cut to give proper engagement in threaded fittings. Threaded pipe shall have clean-cut threads; dull or damaged pipe dies shall not be used.
 - 2. Clean pipe and fittings before installation and ream pipe after cutting threads. Joints shall be made with oil and graphite pipe joint compound applied to male threads only.
- C. Fittings: All pipe intersections and all changes in direction shall be made with factory-built-reinforced fittings. Field-fabricated fittings and miters are not permitted.
- D. Flanged Joints: Gaskets and bolting shall be applied in accordance with the recommendations of the gasket manufacturer and bolting standards of ASME B31.1. Strains shall be evenly applied without overstress of bolts. Gaskets shall cover entire area of mating faces of flanges.

3.04 CLEANING OF PIPING

- A. Clean pipe and fittings inside and outside before and after assembly. Remove all dirt, scale, and other foreign matter from inside the piping by use of a pipe swab or pipe "pig" before connecting pipe sections, valves, equipment or fittings.

3.05 WELDING

- A. The Contractor is entirely responsible for the quality of the welding and shall:
 - 1. Conduct tests of the welding procedures used by his organization, determine the suitability of the procedures used, determine that the welds made will meet the required tests, and also determine that the welding operators have the ability to make sound welds under standard conditions.
 - 2. Comply with ASME B31.1 and AWS B2.1.
 - 3. Perform all welding operations required for construction and installation of the heat-distribution system.
- B. Qualification of Welders: Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform to the applicable portions of ASME B31.1 and AWS B2.1, and also as outlined below.
- C. Examining Welder: Examine each welder at job site, in the presence of the Resident Engineer (RE)/Contracting Officer's Technical Representative (COTR), to determine the ability of the welder to meet the qualifications required. Test welders for piping for all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall be:
 - 1. Allowed to weld only in the position in which he has qualified.
 - 2. Required to identify his welds with his specific code marking signifying his name and number assigned.
- D. Examination Results: Provide the RE/COTR with a list of names and corresponding code markings. Retest welders that fail to meet the prescribed welding qualifications. Disqualify welders, who fail the second test, for work on the project.
- E. Beveling: Field bevels and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding. Conform to specified standards.
- F. Alignment: Utilize split welding rings or approved alternate method for field joints on all carrier pipes above 50 mm (two inches) to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe. Make field joints 50 mm (two inches) and smaller with welding sockets.
- G. Erection: Piping shall not be split, bent, flattened or otherwise damaged either before, during or after installation. Where the pipe temperature falls to 0 degrees C (32 degrees F) or lower, the pipe shall be heated to approximately 38 degrees C (100 degrees F) for a distance of 300 mm (one foot) on each side of the weld before welding, and the weld shall be finished before the pipe cools to 0 degrees C (32 degrees F).

- H. Defective Welds: Replace and re-inspect defective welds. Repairing defective welds by adding weld material over the defect or by peening will not be permitted. Welders responsible for defective welds must be requalified.
- I. Electrodes: Electrodes shall be stored in a dry heated area, and be kept free of moisture and dampness during fabrication operations. Discard electrodes that have lost part of their coating.
- J. Radiographic Testing: An approved independent testing firm regularly engaged in radiographic testing shall perform radiographic examination of all field welds in the carrier piping of direct-buried systems and concrete trench systems, in manholes and in walk-through tunnels, in accordance with ASME B31.1. Furnish a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project, prior to installing conduit field joints, trench covers, backfilling and hydrostatic testing. All radiographs shall be reviewed and interpreted by an ASNT Certified Level III radiographer, employed by the testing firm, who shall sign the reading report. The RE/COTR reserves the right to review all inspection records, and if any welds inspected are found unacceptable they shall be removed, rewelded, and radiographically reexamined at no cost to the Government.

3.06 DRAIN VALVES AND VENT VALVES

- A. Provide 40 mm (1-1/2 inches) minimum pipe size drain valves on condensate return carrier pipes at all low points in manholes. Provide 25 mm (1 inch) minimum air vent valves in manholes at all high points in condensate return carrier piping.

3.07 PIPE SUPPORT INSTALLATION (IN TRENCHES, TUNNELS, MANHOLES)

- A. Coordinate support locations with structure prior to erection of piping. Arrangement of supports shall facilitate operating, servicing and removal of valves, strainers, and piping specialties. Hanger parts must be marked at the factory with a numbering system keyed to hanger layout Drawings. Layout Drawings must be available at the site during construction.
- B. Upper Attachments to Structure:
 - 1. New Reinforced Concrete Construction: Concrete inserts.
 - 2. Existing Reinforced Concrete Construction: Upper attachment welded or clamped to steel clip angles (or other construction shown on the Drawings) that are expansion-bolted to the concrete. Expansion bolting shall be located so that loads place bolts in shear.
 - 3. Steel Deck and Structural Framing: Upper attachments welded or clamped to structural steel members.
- C. Expansion Fasteners and Power Set Fasteners: In existing concrete construction, expansion fasteners may be used for hanger loads up to one-third the manufacturer's rated strength of the expansion fastener. Power set fasteners may be used for loads up to one-fourth of rated load. When greater hanger loads are encountered, additional fasteners may be used and interconnected with steel members combining to support the hanger.
- D. Special Supports:
 - 1. Secure horizontal pipes where necessary to prevent vibration or excess sway.

2. Where hangers cannot be adequately secured as specified, make special provisions for hanging and supporting pipe as directed by the RE/COTR.
 3. Do not attach pipe supports, hangers, clamps or anchors to equipment unless specified for that equipment or unless the RE/COTR gives written permission.
- E. Spring Hangers: Locate spring units within 300 mm (one foot) of the pipe attachment, except in locations where spring assemblies interfere with pipe insulation.
- F. Minimum Clearances in Tunnels and Trenches:
1. Floor to bottom of pipe support beam: 50 mm (two inches).
 2. Floor to bottom of pipe insulation jacket: 150 mm (six inches).
 3. Wall to side of pipe insulation jacket: 75 mm (three inches).
 4. Ceiling to top of pipe insulation jacket: 25 mm (one inch).

3.08 PAINTING EXPOSED STEEL SURFACES IN MANHOLES, TUNNELS AND CONCRETE SHALLOW TRENCHES

- A. Manholes and Walk-Through Tunnels: Provide surface cleaning and preparation and apply prime coat of rust resistant metal primer.

3.09 DIRECT-BURIED SYSTEM INSTALLATION

- A. The system manufacturer shall oversee the delivery, storage, installation and testing of the system. All work shall be in strict accordance with the requirements specified herein and with the printed instructions of the manufacturer. Printed instructions must be available at the site prior to delivery of system components. Any changes required to the design and layout of the system due to site conditions must be approved in writing by the system designer and the RE/COTR. All branch piping connections, valves and drip traps must be located within manholes.
- B. Excavation, Trenching, and Backfilling: Perform all excavation, trenching, and backfilling as required by the system manufacturer's design. Beach sand or any sand with large amounts of chlorides is not permitted. Place system on a 300 mm (12 inch) thick sand bed and backfill on all sides with 150 mm (6 inch) thick sand as measured from outside the casing. Foundation for system must be firm and stable. Foundation and backfill must be free from rocks or substances that could damage the system coating. Concrete anchor and thrust blocks must be installed in undisturbed earth. Backfilling must not commence until elevations have been surveyed and accepted and system has been satisfactorily pressure tested including hydrostatic testing of carrier pipes and air testing of casings.
- C. Representative of System Manufacturer: This shall be a person who regularly performs the duties listed below, is certified in writing by the system manufacturer to be technically qualified and experienced in the installation of the system, and shall be authorized by the manufacturer to make and sign the daily reports specified herein. The representative shall be present at the job site when the following types of work are being performed:
1. Inspection and unloading of material delivered to site.
 2. Inspection of trench prior to commencing installation of system.
 3. Inspection of concrete anchors and thrust blocks.
 4. Cold springing.

5. Hydrostatic test of all service lines.
6. Field joint closure work.
7. Air test of conduit.
8. Repair of any coatings.
9. Holiday test of conduit coating.
10. Installation of cathodic protection system.
11. Initial backfill up to 250 mm (10 inches) above the top of the casing.
12. The slope of the system. Elevation readings shall be witnessed and recorded.
13. Testing of cathodic protection system.
14. Operational tests.

D. Reports to Contracting Officer:

1. Obtain a written report prepared daily and signed by the representative of the system manufacturer. Present the original report to the RE/COTR on the same day it is prepared, and forward one copy to the manufacturer's main office.
2. The report shall state whether or not the condition and quality of the materials used and the delivery, storage, installation and testing of the system are in accordance with the plans, specifications, and manufacturer's printed instructions and is satisfactory in all respects. When any work connected with the installation is unsatisfactory, the report shall state what corrective action has been taken or shall contain the system manufacturer's recommendations for corrective action. The report shall identify any conditions that could result in an unsatisfactory installation, including such items as open conduit ends left in the trench overnight and improper manhole entries. The daily reports are to be reviewed, signed and sealed by the Professional Engineer responsible for the system design. Signed and sealed copies of the daily report shall be submitted with the payment requests. All work must stop if daily reports are not furnished and requests for payments shall be denied if the daily reports are not furnished as specified.
3. Upon completion of the work and before final acceptance, deliver to the RE/COTR a notarized Certificate of Compliance signed by principal officers of both the manufacturing and the contracting firm, stating that the installation is satisfactory and in accordance with plans, specifications and manufacturer's instructions.
4. The manufacturer shall retain copies of all the daily reports and the Certificate of Compliance for 5 years after final acceptance of the system by the Government.

E. Protect casing coating from damage during rigging, storage and installation. Protect casing and carrier pipe ends from water intrusion during rigging and installation. Protect casing coatings from ultraviolet light (sunlight).

F. Defective Material: The Representative shall take prompt action to return to the factory all damaged or defective material and shall order prompt replacement of such material.

G. Slope of Carrier Pipes: Maintain constant slope as shown or specified. Prior to backfilling over the top of the casing, but after removal of temporary supports, Contractor shall measure and record elevations of top of casing in the trench. Elevations shall be taken at every field joint, 1/3 points along each pipe section, and at tops of elbows. These measurements shall be checked against contract Drawings and shall confirm that the conduit system has been installed to the elevations shown on the contract Drawings. Slope shall be uniform within 0.1 percent. These measurements shall be recorded by the

Contractor, included in the direct buried system manufacturer representative's daily report, and given to the RE/COTR prior to covering the top of the casing with backfill.

- H. Cleaning of Piping: Remove all dirt, scale, and other foreign matter from inside the piping by use of a pipe swab or pipe "pig" before connecting pipe sections, valves or fittings.
- I. Wet Insulation: Sections of system that have been fully or partially submerged in water must be replaced. Moisture content of insulation during installation shall not exceed five percent by weight.
- J. Vents and Drains on Ends of DDT Systems: At each casing termination (end plate) in buildings and manholes, plug the casing drain openings with brass plugs and extend one inch pipe size ASTM A53 galvanized vent pipes from the casing vents through the tops of the manholes or one foot above the conduit in buildings. Terminate the outside vents in 180-degree bends.
- K. Buried Utility Warning Tape: Install tape 300 mm (12 inches) below grade above the piping system.

3.10 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

- A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments that will be imposed.
- B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.
- C. Preparation for Service: Clean all sliding surfaces, add packing as necessary, remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.
- D. Access: Expansion joints must be located in readily accessible manhole or in walk-through tunnel. Locate joints to permit access without removing piping or other devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding packing.

3.11 INSTALLATION – VALVES

- A. Do not locate valve stems below the horizontal centerline of the pipe.
- B. Locate valves to permit access for operation, maintenance, and replacement.
- C. Provide 19 mm (3/4 inch) globe-valved warm-up bypasses at all steam gate and butterfly valves 80 mm (3 inch) pipe size and larger.
- D. Provide 19 mm (3/4 inch) gate or ball-valved drains at each side of steam gate and butterfly valves where condensate could collect, due to the slope of the pipeline, when the main valve is shut.

3.12 THERMAL INSULATION

- A. Steam, condensate and drip return piping shall be insulated as follows:

1. Exposed piping in walk-through tunnels shall be insulated with calcium silicate, fiberglass, or cellular glass pipe insulation (all with aluminum jacket). Condensate return piping may be insulated with rigid cellular phenolic with aluminum jacket.
2. Minimum Insulation Thickness: Insulation thicknesses given in Table 5 and 6 are manufacturer's nominal thickness.

TABLE 5 Minimum Pipe Insulation Thickness mm (inches) For Steam 110 to 1724 kPa (16 to 250 psi) gauge					
Nominal Diameter (inches)	Pipe mm	MPT-PC MPT-PF	Delta	Thermo-12 Caltemp	Super Foamglas
25 (1)		50 (2)	63 (2 1/2)	100 (4)	110 (4 1/2)
40 (1 1/2)		50 (2)	63 (2 1/2)	100 (4)	110 (4 1/2)
50 (2)		63 (2 1/2)	85 (3 1/2)	110 (4 1/2)	125 (5)
65 (2 1/2)		63 (2 1/2)	85 (3 1/2)	110 (4 1/2)	125 (5)
80 (3)		75 (3)	100 (4)	125 (5)	150 (6)
100 (4)		75 (3)	100 (4)	125 (5)	150 (6)
125 (5)		75 (3)	100 (4)	125 (5)	150 (6)
150 (6)		85 (3 1/2)	110 (4 1/2)	135 (5 1/2)	150 (6)
200 (8)		85 (3 1/2)	110 (4 1/2)	135 (5 1/2)	150 (6)
250 (10)		100 (4)	125 (5)	150 (6)	165 (6 1/2)
300 (12)		100 (4)	125 (5)	150 (6)	165 (6 1/2)
350 (14)		100 (4)	125 (5)	150 (6)	165 (6 1/2)
400 (16)		100 (4)	125 (5)	150 (6)	165 (6 1/2)
450 (18)		100 (4)	125 (5)	150 (6)	165 (6 1/2)

TABLE 6 Minimum Pipe Insulation Thickness mm, (inches) For Steam less than 110 kPa (16 psi) gauge, Condensate Return					
Nominal Diameter (inches)	Pipe mm	MPT-PC MPT-PF	Delta	Foamglas Thermo-12 Caltemp	Super Insul-phen
25 (1) and under		35 (1 1/2)	50 (2)	75 (3)	25 (1)
40 (1 1/2)		35 (1 1/2)	50 (2)	75 (3)	25 (1)
50 (2)		35 (1 1/2)	50 (2)	75 (3)	25 (1)
65 (2 1/2)		35 (1 1/2)	50 (2)	75 (3)	25 (1)
80 (3)		50 (2)	63 (2 1/2)	85 (3 1/2)	25 (1)
100 (4)		50 (2)	63 (2 1/2)	85 (3 1/2)	38 (1 1/2)
125 (5)		50 (2)	63 (2 1/2)	85 (3 1/2)	38 (1 1/2)
150 (6)		63 (2 1/2)	76 (3)	110 (4 1/2)	38 (1 1/2)
200 (8)		63 (2 1/2)	76 (3)	110 (4 1/2)	38 (1 1/2)

- a. Insulation listed has passed a boiling test:
- b. Delta is available from Rockwool Manufacturing Co., Leeds, Alabama.
- c. Foamglass is available from Pittsburgh Corning Corp., Pittsburgh, Pennsylvania.
- d. MPT is available from Mineral Products of Texas, Houston, Texas.
- e. Thermo-12 and Super Caltemp are available from Johns-Manville, Denver, Colorado.

- f. Insul-phen is available from Resolco International Div., www.resolco.com.

5. Parts Not Insulated:

- a. Threaded valves
- b. Steam traps
- c. Check valves
- d. Unions
- e. Threaded strainers
- f. Strainer basket removal cover and bolting
- g. Dielectric flanges and unions
- h. Expansion joints
- i. Flexible connectors
- j. Ball joints except piping between joints

6. Installation:

- a. Complete all pressure tests before installing insulation.
- b. All insulation material shall be new, clean, dry and stored in a clean dry environment; jacketing materials shall be clean and unmarred; store adhesives in original containers. Materials shall not have exceeded the predicted shelf life as set by manufacturer.
- c. Identify all materials incorporated in the job on manufacturer's container by name, type and description.
- d. Apply materials on clean, dry surfaces from which all dirt, loose scale, construction debris has been removed by wire brushing.
- e. The installation shall be neat, thermally and structurally tight without sag, neatly finished at all hanger or other penetrations and shall provide a smooth finished surface primed as required to receive specified painting.
- f. Do not use scrap insulation. Repair any work damaged by welding, burning, compressing due to concentrated construction loads.
- g. Apply pipe covering protection saddles (MSS SP-58, Type 39) at all hanger points. Fill space between saddle and piping with high density insulation, thoroughly packed. Terminate jacket clear of saddle bearing area.
- h. Insulation and jacket shall terminate hard and tight at all anchor points.
- i. Insulation termination at piping facilities not to be insulated shall stop short, and be finished with 45 degree chamfered section of insulating and finishing cement, and covered with jacket.
- j. Flanged fittings and valves shall be insulated with sections of pipe insulation cut, fitted and arranged neatly, and firmly wired in place. Insulating cement shall fill all cracks, voids and outer surface for covering with glass cloth. Insulation of valve bonnet shall terminate on valve side of bonnet flange to permit valve repair.
- k. On calcium silicate, cellular glass and rigid cellular phenolic insulated piping systems, fittings shall be insulated with field or factory-shaped sections of insulation, finished with specified insulating and finishing cements and covered with jacket or PVC premolded cover. On sizes 50 mm (two inches) and smaller it is permissible to apply insulating and finishing cements, and cover with jacket or PVC premolded cover.
- l. Fiberglass insulated piping systems fittings over 50 mm (two inch) size shall be insulated with specified molded pipe fitting insulation or compressed blanket, finished with specified insulating and finishing cements and covered with specified PVC fitting jacket. On sizes 50 mm (two inches) and under apply insulating and finishing cements and cover with PVC fitting jacket.

- m. Apply glass cloth jacket using an approved adhesive. Glass cloth shall be smooth, tight and neatly finished at all edges; prime cloth to receive paint specified in Section 09 91 00 - Painting.

3.13 BURIED UTILITY WARNING TAPE

- A. Bury directly above direct-buried system approximately 300 mm (12 inches) below grade.

3.14 IDENTIFICATION SIGNS

- A. Valve Identification: Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, on all isolating valves on steam and condensate return system, identifying building or area served. Attach to the valves with corrosion-resistant chains.

3.15 TESTS

- A. Demonstrate leak-tightness of all piping systems by performing hydrostatic and operational tests. All labor, material and test instruments must be furnished by the Contractor. All instruments must be approved by the RE/COTR.
- B. Pressure test direct-buried systems in conformance with requirements stated in this specification and in printed instructions for the system supplied. Tests must include carrier piping and casing.
- C. Holiday testing of direct-buried system steel casings: Test entire surface of casings for faults in coating after installation in trench prior to backfilling. Use test method and voltage recommended by coating manufacturer. Repair any holidays found and retest. System shall not be backfilled until all holidays are eliminated.
- D. Radiographic testing of carrier pipe welds: Refer to Article, "Welding," in Part 3 of this specification.
- E. Before conducting steam system operating test, remove steam trap elements or use bypass connections around traps; then flush lines with high pressure water until discharge shows no foreign matter to the satisfaction of RE/COTR.
- F. Hydrostatic and Operational Tests of Carrier Piping: Steam and condensate carrier piping shall be tested hydrostatically before insulation is applied at field joints and shall be proved tight at a pressure 1-1/2 times distribution supply pressure for a period not less than 2 hours with no pressure decay.
 - 1. Test piping located in concrete trenches prior to installing trench covers. Test direct-buried systems prior to backfilling.
 - 2. Remove or isolate any elements of the system such as expansion joints, which are not designed for the test pressure.
 - 3. Prior to acceptance of installation, Contractor shall subject system to operating tests as may be required by RE/COTR to demonstrate satisfactory functional and operating efficiency. These operating tests shall cover a period of not less than six hours for each portion of system tested. Conduct tests at times as the RE/COTR may direct.

4. Provide calibrated instruments, equipment, facilities and labor, at no additional cost to the Government. Test gauge shall read in increments not exceeding 1 kPa (0.1 psi).
 5. Repeat tests when failures occur.
 6. After completion of satisfactory test, replace all elements that have been removed prior to testing.
- G. Pneumatic Testing of DDT System Casings:
1. Perform test on all sections of the system before field-coating the field joints and before back-filling.
 2. Test shall be with compressed air at 100 kPa (15 psi) for 24 hours with pressure source disconnected and with no decay in pressure. Corrections to the readings are permissible to compensate for significant ambient temperature changes during the test period.
 3. Pressure shall be measured with a gauge with reading increments of 1 kPa (0.1 psi).
 4. Each casing field joint shall be tested for leaks by means of soap solution or equivalent.
- H. NACE-accredited corrosion specialist shall test cathodic protection systems and demonstrate proper operation and protection in accordance with the recommendations and criteria in NACE RP0169 and in Section 26 42 00 – Cathodic Protection.
- I. Deficiencies discovered shall be corrected at the Contractor's expense, to satisfaction of RE/COTR. Major deficiencies or failure to correct deficiencies, to the satisfaction of the RE/COTR, may be considered cause for rejecting the entire installation.

END OF SECTION

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Refer to the latest edition of all referenced Standards and codes.
- B. American Association of State Highway and Transportation Officials (AASHTO):
- M031MM031-07-UL Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement (ASTM A615/A615M-09)
- M055MM055-09-UL Steel Welded Wire Reinforcement, Plain, for Concrete (ASTM A185)
- M147-65-UL Materials for Aggregate and Soil-Aggregate Subbase, Base and Surface Courses (R 2004)
- M148-05-UL Liquid Membrane-Forming Compounds for Curing Concrete (ASTM C309)
- M171-05-UL Sheet Materials for Curing Concrete (ASTM C171)
- M182-05-UL Burlap Cloth Made from Jute or Kenaf and Cotton Mats
- M213-01-UL Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Type) (ASTM D1751)
- M233-86-UL Boiled Linseed Oil Mixer for Treatment of Portland Cement Concrete
- T099-09-UL Moisture-Density Relations of Soils Using a 2.5 kg. (5.5 lb) Rammer and a 305 mm (12 in.) Drop
- T180-09-UL Moisture-Density Relations of Soils Using a 4.54 kg (10 lb.) Rammer and a 457 mm (18 in.) Drop
- C. American Society for Testing and Materials (ASTM):
- C94/C94M-09..... Ready-Mixed Concrete
- C143/C143M-09..... Slump of Hydraulic Cement Concrete

PART 2 - PRODUCTS

2.1 GENERAL

Concrete shall be Type C, air-entrained as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, with the following exceptions:

TYPE	MAXIMUM SLUMP*
Curb & Gutter	75 mm (3")
Pedestrian Pavement	75 mm (3")

Vehicular Pavement	50 mm (2") (Machine Finished) 100 mm (4") (Hand Finished)
Equipment Pad	75 to 100 mm (3" to 4")
* For concrete to be vibrated: Slump as determined by ASTM C143. Tolerances as established by ASTM C94.	

2.2 REINFORCEMENT

- A. The type, amount, and locations of steel reinforcement shall be as shown on the drawings and in the specifications.
- B. Welded wire-fabric shall conform to AASHTO M55.
- C. Dowels shall be plain steel bars conforming to AASHTO M31. Tie bars shall be deformed steel bars conforming to AASHTO M31.

2.3 SELECT SUBBASE (WHERE REQUIRED)

- A. Subbase material shall consist of select granular material composed of sand, sand-gravel, crushed stone, crushed or granulated slag, with or without soil binder, or combinations of these materials conforming to AASHTO M147, Grading E or F.
- B. Materials meeting other gradations than that noted will be acceptable whenever the gradations are within a tolerance of three to five percent, plus or minus, of the single gradation established by the job-mix formula.
- C. Subbase material shall produce a compacted, dense-graded course, meeting the density requirement specified herein.

2.4 FORMS

- A. Use metal or wood forms that are straight and suitable in cross-section, depth, and strength to resist springing during depositing and consolidating the concrete, for the work involved.
- B. Do not use forms if they vary from a straight line more than 3 mm (1/8 inch) in any 3000 mm (ten foot) long section, in either a horizontal or vertical direction.
- C. Wood forms should be at least 50 mm (2 inches) thick (nominal). Wood forms shall also be free from warp, twist, loose knots, splits, or other defects. Use approved flexible or curved forms for forming radii.

2.5 CONCRETE CURING MATERIALS

- A. Concrete curing materials shall conform to one of the following:
 - 1. Burlap conforming to AASHTO M182 having a weight of 233 grams (seven ounces) or more per square meter (yard) when dry.
 - 2. Impervious Sheeting conforming to AASHTO M171.
 - 3. Liquid Membrane Curing Compound conforming to AASHTO M148 (ASTM C309), Type 1 and shall be free of paraffin or petroleum.

2.6 EXPANSION JOINT FILLERS

Material shall conform to AASHTO M213.

PART 3 - EXECUTION

3.1 SUBGRADE PENETRATION

- A. Prepare, construct, and finish the subgrade as specified in Section 31 20 00, EARTH MOVING.
- B. Maintain the subgrade in a smooth, compacted condition, in conformance with the required section and established grade until the succeeding operation has been accomplished.

3.2 SELECT SUBBASE (WHERE REQUIRED)

- A. Mixing: Proportion the select subbase by weight or by volume in quantities so that the final approved job-mixed formula gradation, liquid limit, and plasticity index requirements will be met after subbase course has been placed and compacted. Add water in approved quantities, measured by weight or volume, in such a manner to produce a uniform blend.
- B. Placing:
 - 1. Place the mixed material on the prepared subgrade in a uniform layer to the required contour and grades, and to a loose depth not to exceed 200 mm (8 inches), and that when compacted, will produce a layer of the designated thickness.
 - 2. When the designated compacted thickness exceeds 150 mm (6 inches), place the material in layers of equal thickness. Remove unsatisfactory areas and replace with satisfactory mixture, or mix the material in the area.
 - 3. In no case will the addition of thin layers of material be added to the top layer in order to meet grade.
 - 4. If the elevation of the top layer is 13 mm (1/2 inch) or more below the grade, excavate the top layer and replace with new material to a depth of at least 75 mm (3 inches) in compacted thickness.
- C. Compaction:
 - 1. Perform compaction with approved equipment (hand or mechanical) well suited to the material being compacted.
 - 2. Moisten or aerate the material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.
 - 3. Compact each layer to at least 95 percent or 100 percent of maximum density as determined by AASHTO T180 or AASHTO T99 respectively.
- D. Smoothness Test and Thickness Control:

Test the completed subbase for grade and cross section with a straight edge.

 - 1. The surface of each layer shall not show any deviations in excess of 10 mm (3/8 inch).
 - 2. The completed thickness shall be within 13 mm (1/2 inch) of the thickness as shown.
- E. Protection:

1. Maintain the finished subbase in a smooth and compacted condition until the concrete has been placed.
2. When Contractor's subsequent operations or adverse weather disturbs the approved compacted subbase, excavate, and reconstruct it with new material meeting the requirements herein specified, at no additional cost to the VA.

3.3 SETTING FORMS

A. Base Support:

1. Compact the base material under the forms true to grade so that, when set, they will be uniformly supported for their entire length at the grade as shown.
2. Correct imperfections or variations in the base material grade by cutting or filling and compacting.

B. Form Setting:

1. Set forms sufficiently in advance of the placing of the concrete to permit the performance and approval of all operations required with and adjacent to the form lines.
2. Set forms to true line and grade and use stakes, clamps, spreaders, and braces to hold them rigidly in place so that the forms and joints are free from play or movement in any direction.
3. Forms shall conform to line and grade with an allowable tolerance of 3 mm (1/8 inch) when checked with a straightedge and shall not deviate from true line by more than 6 mm (1/4 inch) at any point.
4. Do not remove forms until removal will not result in damaged concrete or at such time to facilitate finishing.
5. Clean and oil forms each time they are used.

C. The Contractor's Registered Professional Land Surveyor, specified in Section 00 72 00, GENERAL CONDITIONS, shall establish and control the alignment and the grade elevations of the forms or concrete slipforming machine operations.

1. Make necessary corrections to forms immediately before placing concrete.
2. When any form has been disturbed or any subgrade or subbase has become unstable, reset and recheck the form before placing concrete.

3.4 EQUIPMENT

- A. The Resident Engineer shall approve equipment and tools necessary for handling materials and performing all parts of the work prior to commencement of work.
- B. Maintain equipment and tools in satisfactory working condition at all times.

3.5 PLACING REINFORCEMENT

- A. Reinforcement shall be free from dirt, oil, rust, scale or other substances that prevent the bonding of the concrete to the reinforcement.

- B. Before the concrete is placed, the Resident Engineer shall approve the reinforcement, which shall be accurately and securely fastened in place with suitable supports and ties. The type, amount, and position of the reinforcement shall be as shown.

3.6 PLACING CONCRETE - GENERAL

- A. Obtain approval of the Resident Engineer before placing concrete.
- B. Remove debris and other foreign material from between the forms before placing concrete.
Obtain approval of the Resident Engineer before placing concrete.
- C. Before the concrete is placed, uniformly moisten the subgrade, base, or subbase appropriately, avoiding puddles of water.
- D. Convey concrete from mixer to final place of deposit by a method which will prevent segregation or loss of ingredients. Deposit concrete so that it requires as little handling as possible.
- E. While being placed, spade or vibrate and compact the concrete with suitable tools to prevent the formation of voids or honeycomb pockets. Vibrate concrete well against forms and along joints. Over-vibration or manipulation causing segregation will not be permitted. Place concrete continuously between joints without bulkheads.
- F. Install a construction joint whenever the placing of concrete is suspended for more than 30 minutes and at the end of each day's work.
- G. Workmen or construction equipment coated with foreign material shall not be permitted to walk or operate in the concrete during placement and finishing operations.

3.7 PLACING CONCRETE FOR CURB AND GUTTER, PEDESTRIAN PAVEMENT, AND EQUIPMENT PADS

- A. Place concrete in the forms in one layer of such thickness that, when compacted and finished, it will conform to the cross section as shown.
- B. Deposit concrete as near to joints as possible without disturbing them but do not dump onto a joint assembly.
- C. After the concrete has been placed in the forms, use a strike-off guided by the side forms to bring the surface to the proper section to be compacted.
- D. Consolidate the concrete thoroughly by tamping and spading, or with approved mechanical finishing equipment.
- E. Finish the surface to grade with a wood or metal float.
- F. All Concrete pads and pavements shall be constructed with sufficient slope to drain properly.

3.8 PLACING CONCRETE FOR VEHICULAR PAVEMENT

- A. Deposit concrete into the forms as close as possible to its final position.
- B. Place concrete rapidly and continuously between construction joints.
- C. Strike off concrete and thoroughly consolidate by a finishing machine, vibrating screed, or by hand-finishing.
- D. Finish the surface to the elevation and crown as shown.

- E. Deposit concrete as near the joints as possible without disturbing them but do not dump onto a joint assembly. Do not place adjacent lanes without approval by the Resident Engineer.

3.9 CONCRETE FINISHING - GENERAL

- A. The sequence of operations, unless otherwise indicated, shall be as follows:
 - 1. Consolidating, floating, straight-edging, troweling, texturing, and edging of joints.
 - 2. Maintain finishing equipment and tools in a clean and approved condition.

3.10 CONCRETE FINISHING CURB AND GUTTER

- A. Round the edges of the gutter and top of the curb with an edging tool to a radius of 6mm (1/4 inch) or as otherwise detailed.
- B. Float the surfaces and finish with a smooth wood or metal float until true to grade and section and uniform in textures.
- C. Finish the surfaces, while still wet, with a bristle type brush with longitudinal strokes.
- D. Immediately after removing the front curb form, rub the face of the curb with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Brush the surface, while still wet, in the same manner as the gutter and curb top.
- E. Except at grade changes or curves, finished surfaces shall not vary more than 3 mm (1/8 inch) for gutter and 6 mm (1/4 inch) for top and face of curb, when tested with a 3000 mm (10 foot) straightedge.
- F. Remove and reconstruct irregularities exceeding the above for the full length between regularly scheduled joints.
- G. Correct any depressions which will not drain.
- H. Visible surfaces and edges of finished curb, gutter, and combination curb and gutter shall be free of blemishes, form marks, and tool marks, and shall be uniform in color, shape, and appearance.

3.11 CONCRETE FINISHING PEDESTRIAN PAVEMENT

- A. Walks, Wheelchair Curb Ramps:
 - 1. Finish the surfaces to grade and cross section with a metal float, trowled smooth and finished with a broom moistened with clear water.
 - 2. Brooming shall be transverse to the line of traffic.
 - 3. Finish all slab edges, including those at formed joints, carefully with an edger having a radius as shown on the Drawings.
 - 4. Unless otherwise indicated, edge the transverse joints before brooming. The brooming shall eliminate the flat surface left by the surface face of the edger. Execute the brooming so that the corrugation, thus produced, will be uniform in appearance and not more than 2 mm (1/16 inch) in depth.
 - 5. The completed surface shall be uniform in color and free of surface blemishes, form marks, and tool marks. The finished surface of the pavement shall not vary more than 5 mm (3/16 inch) when tested with a 3000 mm (10 foot) straightedge.

6. The thickness of the pavement shall not vary more than 6 mm (1/4 inch).
 7. Remove and reconstruct irregularities exceeding the above for the full length between regularly scheduled joints.
- B. Steps: The method of finishing the steps and the sidewalls is similar to above except as herein noted.
1. Remove the riser forms one at a time, starting with the top riser.
 2. After removing the riser form, rub the face of the riser with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. Use an outside edger to round the corner of the tread; use an inside edger to finish the corner at the bottom of the riser.
 3. Give the risers and sidewall a final brush finish. The treads shall have a final finish with a stiff brush to provide a non-slip surface.
 4. The texture of the completed steps shall present a neat and uniform appearance and shall not deviate from a straightedge test more than 5 mm (3/16 inch).

3.12 CONCRETE FINISHING FOR VEHICULAR PAVEMENT

- A. Accomplish longitudinal floating with a longitudinal float not less than 3000 mm (10 feet) long and 150 mm (6 inches) wide, properly stiffened to prevent flexing and warping. Operate the float from foot bridges in a sawing motion parallel to the direction in which the pavement is being laid from one side of the pavement to the other, and advancing not more than half the length of the float.
- B. After the longitudinal floating is completed, but while the concrete is still plastic, eliminate minor irregularities in the pavement surfaces by means of metal floats, 1500 mm (5 feet) in length, and straightedges, 3000 mm (10 feet) in length. Make the final finish with the straightedges, which shall be used to float the entire pavement surface.
- C. Test the surface for trueness with a 3000 mm (10 foot) straightedge held in successive positions parallel and at right angles to the direction in which the pavement is being laid and the entire area covered as necessary to detect variations. Advance the straightedge along the pavement in successive stages of not more than one half the length of the straightedge. Correct all irregularities and refinish the surface.
- D. The finished surface of the pavement shall not vary more than 6 mm (1/4 inch) in both longitudinal and transverse directions when tested with a 3000 mm (10 foot) straightedge.
- E. The thickness of the pavement shall not vary more than 6 mm (1/4 inch).
- F. When most of the water glaze or sheen has disappeared and before the concrete becomes nonplastic, give the surface of the pavement a broomed finish with an approved fiber broom not less than 450 mm (18 inches) wide. Pull the broom gently over the surface of the pavement from edge to edge. Brooming shall be transverse to the line of traffic and so executed that the corrugations thus produced will be uniform in character and width, and not more than 3 mm (1/8

inch) in depth. Carefully finish the edge of the pavement along forms and at the joints with an edging tool. The brooming shall eliminate the flat surface left by the surface face of the edger.

G. The finish surfaces of new and existing abutting pavements shall coincide at their juncture.

3.13 CONCRETE FINISHING EQUIPMENT PADS

- A. After the surface has been struck off and screeded to the proper elevation, give it a smooth dense float finish, free from depressions or irregularities.
- B. Carefully finish all slab edges with an edger having a radius as shown in the Drawings.
- C. After removing the forms, rub the faces of the pad with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The finish surface of the pad shall not vary more than 3 mm (1/8 inch) when tested with a 3000 mm (10 foot) straightedge.
- D. Correct irregularities exceeding the above.

3.14 JOINTS - GENERAL

- A. Place joints, where shown, conforming to the details as shown, and perpendicular to the finished grade of the concrete surface.
- B. Joints shall be straight and continuous from edge to edge of the pavement.

3.15 CONTRACTION JOINTS

- A. Cut joints to depth as shown with a grooving tool or jointer of a radius as shown or by sawing with a blade producing the required width and depth.
- B. Construct joints in curbs and gutters by inserting 3 mm (1/8 inch) steel plates conforming to the cross sections of the curb and gutter.
- C. Plates shall remain in place until concrete has set sufficiently to hold its shape and shall then be removed.
- D. Finish edges of all joints with an edging tool having the radius as shown.
- E. Score pedestrian pavement with a standard grooving tool or jointer.

3.16 EXPANSION JOINTS

- A. Use a preformed expansion joint filler material of the thickness as shown to form expansion joints.
- B. Material shall extend the full depth of concrete, cut and shaped to the cross section as shown, except that top edges of joint filler shall be below the finished concrete surface where shown to allow for sealing.
- C. Anchor with approved devices to prevent displacing during placing and finishing operations.
- D. Round the edges of joints with an edging tool.
- E. Form expansion joints as follows:
 - 1. Without dowels, about structures and features that project through, into, or against any site work concrete construction.
 - 2. Using joint filler of the type, thickness, and width as shown.
 - 3. Installed in such a manner as to form a complete, uniform separation between the structure and the site work concrete item.

3.17 CONSTRUCTION JOINTS

- A. Locate longitudinal and transverse construction joints between slabs of vehicular pavement as shown.
- B. Place transverse construction joints of the type shown, where indicated and whenever the placing of concrete is suspended for more than 30 minutes.
- C. Use a butt-type joint with dowels in curb and gutter if the joint occurs at the location of a planned joint.
- D. Use keyed joints with tiebars if the joint occurs in the middle third of the normal curb and gutter joint interval.

3.18 FORM REMOVAL

- A. Forms shall remain in place at least 12 hours after the concrete has been placed. Remove forms without injuring the concrete.
- B. Do not use bars or heavy tools against the concrete in removing the forms. Promptly repair any concrete found defective after form removal.

3.20 CURING OF CONCRETE

- A. Cure concrete by one of the following methods appropriate to the weather conditions and local construction practices, against loss of moisture, and rapid temperature changes for at least seven days from the beginning of the curing operation. Protect unhardened concrete from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready to install before actual concrete placement begins. Provide protection as necessary to prevent cracking of the pavement due to temperature changes during the curing period. If any selected method of curing does not afford the proper curing and protection against concrete cracking, remove and replace the damaged pavement and employ another method of curing as directed by the Resident Engineer.
- B. Burlap Mat: Provide a minimum of two layers kept saturated with water for the curing period. Mats shall overlap each other at least 150 mm (6 inches).
- C. Impervious Sheeting: Use waterproof paper, polyethylene-coated burlap, or polyethylene sheeting. Polyethylene shall be at least 0.1 mm (4 mils) in thickness. Wet the entire exposed concrete surface with a fine spray of water and then cover with the sheeting material. Sheets shall overlap each other at least 300 mm (12 inches). Securely anchor sheeting.
- D. Liquid Membrane Curing:
 - 1. Apply pigmented membrane-forming curing compound in two coats at right angles to each other at a rate of 5 m²/L (200 square feet per gallon) for both coats.
 - 2. Do not allow the concrete to dry before the application of the membrane.
 - 3. Cure joints designated to be sealed by inserting moistened paper or fiber rope or covering with waterproof paper prior to application of the curing compound, in a manner to prevent the curing compound entering the joint.

4. Immediately re-spray any area covered with curing compound and damaged during the curing period.

3.21 CLEANING

- A. After completion of the curing period:
 1. Remove the curing material (other than liquid membrane).
 2. Sweep the concrete clean.
 3. After removal of all foreign matter from the joints, seal joints as herein specified.
 4. Clean the entire concrete of all debris and construction equipment as soon as curing and sealing of joints has been completed.

3.22 PROTECTION

The contractor shall protect the concrete against all damage prior to final acceptance by the Government. Remove concrete containing excessive cracking, fractures, spalling, or other defects and reconstruct the entire section between regularly scheduled joints, when directed by the Resident Engineer, and at no additional cost to the Government. Exclude traffic from vehicular pavement until the concrete is at least seven days old, or for a longer period of time if so directed by the Resident Engineer.

3.23 FINAL CLEAN-UP

Remove all debris, rubbish and excess material from the Station.

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